

NATIONAL RAILROAD PASSENGER CORPORATION



THE ART OF SCHEDULING TRAINS
THE IMPACT OF DELAYS
AND
THE ART OF SCHEDULE ANALYSIS

National Railroad Passenger Corporation
Operations Department
Second Edition
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Introduction and Acknowledgments

During 1995, at the request of Private Car Owners, I prepared a paper on the Art of Scheduling Trains. It was presented to the Private Car Owners at Nelson, British Columbia and to the Lexington Group in Transportation History at Portland, Oregon. The strong response we received prompted us to rewrite the paper as a more technical presentation on scheduling and the impact of delays.

In this second edition, the paper on The Art of Scheduling Trains and The Impact of Delays and a companion paper on the Art of Schedule Analysis have been consolidated to provide direction to the course on scheduling and schedule analysis and to assist those who will be trained to conduct schedule evaluations, although there may be some redundancy between the papers.

Several years ago we developed a course on scheduling and schedule analysis that is still used on a regular basis for Amtrak management, and upon request it is also presented to the freight railroad personnel who are involved in analysis of Amtrak schedules. The ability to properly analyze a schedule is truly an art. The following paper is intended to be a guide for people who are qualifying on how to properly evaluate schedules. It is based on experience gained by a small cadre of experienced riders over a 20-year period and represents hundreds of thousands of miles and thousands of hours of making field checks.

I wish to acknowledge the assistance of Arthur Prentiss and Al Walton of my staff who carefully critiqued the draft. I also wish to acknowledge the assistance of Chris Dort and Rande Jones, locomotive engineers for Amtrak who reviewed the final draft of the first edition. I also appreciated the editorial assistance from R. H. Young, Assistant Vice President Passenger Services, CSX; Howard Godwin, Director of Passenger Operations, CSX and Ray Shields, Manager of Passenger Operations, all of whom are certified locomotive engineers as well as Cliff Russ, Director of Passenger Services for CSX, their input was most valuable.

Our final comment to all who are about to board the engine, whether in engine service or to perform a schedule evaluation, is "Have a safe trip."

James L. Larson
Washington, DC
August 8, 1996

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PART I

THE ART OF SCHEDULING

Background:

In 1971, Amtrak inherited the schedules in place at that time on each of the carriers where passenger service was assumed. Some of the schedules were good, some were poor and some needed restringing. Thereafter, performance began to deteriorate. That deterioration continued until the first incentive contracts were negotiated with a limited number of carriers in 1974. However, no concerted effort was made to address the quality of schedules until the Second Amendment contracts were negotiated starting in 1976.

The carriers' solution to improved scheduling was to add more time to the schedules. This, in turn, led to more abuses of passenger train priority which, in turn, led to later trains. Since all performance was measured at endpoints, the carriers sought schedules that were extremely tight to the next to last station and then had virtually all recovery time built into the final terminal on that carrier. That led to performance where a train might be 45 minutes late at the next to last station yet arrive at the final station 20 minutes ahead of time.

The period from 1974 to 1976 under the first incentive agreements was an important learning period for both Amtrak and the freight carriers. There was a growing awareness that properly strung schedules and the elimination of excess time promoted improved performance. Since 1976, Amtrak's schedules have been negotiated with the carriers just as compensation provisions are negotiated.

Subsequently, the addition of intermediate point performance and performance penalties in 1981 further refined the process. When it comes to preparing proper schedules that both Amtrak and the railroads can accept, much has been learned over the years. What was unique about this process was the widespread operation of trackage rights, over 24,000 route miles, where passenger trains were operated over the infrastructure maintained and controlled (dispatched) by another company.

The relationship between Amtrak and the freight railroads has matured over the years and although the working relationship may vary significantly from one carrier to another, in general the working relationship has materially improved, as has the process of developing schedules.

Basic Principles:

The basic principles underlying proper scheduling are quite simple. Too much time in the schedule, the train will run late. Not enough time in the schedule, the train will run late. And with the right amount of time in the schedule, the train may still run late, depending upon delays. The key: (1) having the correct amount of time in the schedule and (2) having the schedule properly strung.

Even though Amtrak is frequently criticized in the media, the fact still remains that nine out of ten Metroliners arrive on time, eight out of ten Northeast Corridor trains arrive on time, and seven out of ten trains overall arrive on time.

Scheduling has three basic components:

- Pure Running Time
- Dwell Time
- Recovery Time

Pure Running Time is based upon running time developed at maximum authorized speeds, without delays, on a predetermined power to weight ratio. The power to weight ratio is the relationship of locomotive horsepower to trailing tonnage. It is a critical factor in scheduling trains.

Pure running time will vary depending upon the maximum authorized speeds and the power to weight ratio; therefore, these factors must be established before the pure running time can be determined.

Establishing the power-to-weight ratio has been somewhat oversimplified in the past by using the number of locomotive units to trailing cars, without regard to the units or the types of cars. Since the F-40 was the predominant locomotive type outside of electrified territory, it was fairly consistent in the establishment of power to weight ratios on all trains operated with F-40 locomotives. The more recent introduction of other diesel locomotive types such as the Dash-8 or P-40 locomotives, which have significantly different power and operating characteristics, has necessitated further

refinement to reflect the "normal" power consist operated on specific trains. Car weights vary generally between 50 tons and 74 tons, depending upon type, but the type of cars operated on a given train normally does not change from day-to-day. However, the number of cars often does.

Each train has a published "normal" consist, and while this establishes a good base for building a power to weight ratio, it should not be used as an average train. Additional cars may be required and, therefore, every time a car is added beyond the "normal" consist, it could adversely affect the power to weight ratio. It is good practice to allow for one or two additional cars in building a schedule so that extra cars can be operated without adversely affecting the performance of the train.

The additional time required for each additional car is not a straight line relationship. For example, with one F-40 locomotive and from four to six cars, the pure running time differences should be negligible. The seventh car may show some differential, depending upon the territory, while the eighth and ninth cars will definitely show a differential and the tenth car is not recommended.

It is interesting to note that the performance of one F-40 and six cars will not be materially different from two F-40's and twelve cars. Although the second train has six extra cars, about 500 feet in length, to pull through each restriction, only one unit provides head end power. Therefore the extra horsepower available for traction

provided by the second unit will generally compensate for the additional train length, as will a third unit with 18 cars.

Summary:

In developing a power to weight ratio, the type of power normally operated on the train, whether it is turbo, electric, or diesel should be used. This should be further refined by type, such as E-60 or AEM-7 or, for diesels, FL-9, F-40, Dash-8, or P-40, or any combination thereof. In selecting the number of trailing cars, the "normal" consist should be used, plus one or two cars to allow for extra cars in addition to the "normal" consist.

Pure Running Time Determination:

Once the power to weight ratio is determined, it can be applied to the authorized speeds to develop the pure running time, generally in one of three ways, as follows:

1. Field Riding Program
2. Manual Desk Calculation
3. Computerized Train Performance Calculation (TPC)

What is amazing is that regardless of the methodology used, the end results are usually very close -- generally within one or two percent.

The field riding program is performed by a team that rides the engine over the entire trip, factors out delays, and measures pure running times and dwell times to the nearest tenth of a minute. This is discussed in detail in a companion paper, "The Art of Schedule Analysis."

The manual desk calculation can be performed by only a very limited number of people who can manually calculate performance including acceleration, braking, curve speeds and other restrictions generally to the nearest tenth of a minute. If done correctly, it can be very accurate. This is used primarily to establish new service where unfinished capital work or other factors prevent actual field tests at prospective speeds.

Finally, TPC programs allow the commuter to calculate performance over a line of railroad with amazing accuracy, provided accurate data are used in the program.

TPC programs are recommended and although they may or may not be as accurate as field tests, which measure actual performance, they are a great time-saver compared to multiple trips on long distance trains. They are especially useful in developing additional running time required for changing power-to-weight ratios. As an example, a TPC evaluation for a train with 2 units and 12 cars can be checked for accuracy with a field test with the same size consist and then used to determine the additional time required for 2 units and 14 cars, 16 cars and 18 cars. The user is cautioned that if the correct coefficients are not used, the results will not be accurate. The following three examples demonstrate common errors:

- (1) The original passenger car rolling resistance factor included a factor for the Spicer drive mechanical transmission under each car which was used to generate power, using roughly 50 horsepower per car; however, modern equipment which uses head end power (HEP) does not have a Spicer Drive. Therefore, if the old rolling resistance factor is used in addition to factoring in the traction horsepower reduction for the HEP load, the resulting factor is a double count.

(2) Head end power is drawn off of only one unit, with a resulting reduction in horsepower available for traction. This train draws only as much power as is actually needed for HEP. The absolute maximum draw is about 625 horsepower from one unit. If horsepower needed to operate HEP is overcounted, the horsepower available for traction is understated.

(3) Some freight railroads use TPC programs which reflect normal freight train braking procedures, which, if applied to passenger trains, substantially overstate the pure running time.

Again, the accuracy of TPC programs should not be understated, provided errors such as those shown above are avoided. Amtrak once had the opportunity to review a TPC printout while making a field test between Seattle and Portland. It was surprising how close the two sets of data were. The TPC, however, failed to reflect that the station at Tacoma had been relocated some years earlier, so it is equally important to have up-to-date and accurate engineering data.

It should be remembered that TPC printouts only produce pure running time and do not include dwell time and recovery time. Recently, one carrier produced a printout that also included hypothetical en route delays which, of course, made the document.

Dwell Time:

This is the amount of time required to perform station work. Smaller stations generally require three minutes or less, as does a crew change. Larger stations require more time depending upon train and locomotive servicing and/or switching, mail, baggage and express.

Dwell time is the second major component in developing satisfactory schedules. Dwell time is important to provide adequate time (but not excess time) to perform station work. It will vary significantly from one station to the next, depending upon requirements. In like manner, it may vary significantly at the same station from one day to the next. Some dwell times are only one minute at small stations. A crew change can be accomplished normally within three minutes. If the number varies significantly from one day to the next, one way to obtain a "normal" dwell is to average the times over a representative period. However this produces an "average," which means that half the time the train is on target or under, and half the time the train uses more than the allotted dwell time. Amtrak recommends the "75% Rule," which says: "Look at the time in the 75th percentile as the normal amount of dwell time required -- the balance is covered by recovery time."

There is a hypothesis that says: "Station work tends to expand to fill all available time." This says that if 15 minutes is currently required at Station "A" and 5 minutes additional time is added, making the scheduled dwell time 20 minutes, the work will, in a

short period of time, expand (or the pace of the work will slow down) to require 20 minutes -- and the recovery time is lost. Adding dwell time beyond actual requirements is not a good practice.

In like manner, adding excess dwell time because there are a lot of skiers on Fridays and Sundays during the season or because the train occasionally carries groups of boy scouts in the summertime is also not a good practice. This adds excess time 180 or 365 days a year for something that occurs perhaps 40 times a year. Again, this is the purpose of recovery time.

What about second stops at a station? Second stops are generally considered evil but may be a necessity. An extra stop generally costs less than two minutes, about one minute to pull forward and a minute or less for loading. Sometimes, the length of the platform or the makeup of a train necessitate second or even third stops. At unstaffed stations, the passengers tend to gather together under the platform light near the closed station building, and even the longest platform will not result in the passengers locating themselves along the platform. At those stations, it is doubtful that even a "wagon locator" such as is used in Europe would make any difference.

Second stops delay trains and therefore their use should be judicious and only as conditions require. At staffed stations, advance notice to the passengers on where to stand should be universal; often it is not done and thus additional stops are required. Alexandria, Virginia, is probably the best station in the nation for having passengers

properly spotted on the platform. Clearly, a second spot is better than walking passengers with their luggage through several cars on a moving train. Conversely, making a second, or even a third spot, just so a crew member can conveniently board the rear of the train is unacceptable.

The key is that if a second or third stop is made on a fairly regular basis, 50 percent or more, the time for the stop should be built into the dwell time. If it occurs seldom or only on a random basis, it should be covered by recovery time.

Other practices such as "streetcarring" passengers (collecting tickets on the platform) can have a disastrous impact upon dwell time. Finally, dwell time requirements may change over a period of time and must be revisited periodically. All employees must be monitored, encouraged and directed where necessary to minimize dwell times.

Summary:

Dwell time should be established to meet the exigencies of the service. Excess dwell time results in the station work expanding (or slowing down) to fill the available time. Additional spots are sometimes necessary, but their use should be judicious and incorporated into dwell times when necessary. Finally, dwell time requirements may change and scheduled dwell time must be adjusted on a recurring basis.

Recovery Time:

Recovery time is time added to the schedule, generally six percent¹ to eight percent, to compensate for all contingencies (delays) encountered en route. It may be as much as three hours per trip on a long distance train.

Recovery time by any other name -- fat, rubber, pad, etc. -- is still recovery time, and it is the third critical factor in proper schedule construction. It is an essential element, and how that time is spaced is addressed in the section on schedule stringing. The key point is:

WHEN THE AMOUNT OF DELAY EXCEEDS THE AVAILABLE RECOVERY TIME, THE TRAIN IS LATE

Negative recovery time will be discussed further in the section on schedule stringing; however, it can be defined as the difference in time when pure running time plus dwell time exceeds schedule time. To put this in perspective, if the pure running time between A and B is 40 minutes, and B has 5 minutes dwell time but the schedule is 43 minutes, there is 0-2.0 minutes recovery time or a negative recovery time of 2 minutes. From a practical standpoint, it means that with a perfect run with no delay and a stop equal to the scheduled dwell time, the train would be two minutes late. Negative

¹ Recovery time can be measured as a percent of pure running time only, or as a percent of pure running time plus dwell time, which together are sometimes called the "base schedule."

recovery time was an old scheduling practice to keep the schedule tight; the train would never wait for time because it could never make its schedule. It is not currently a recommended practice because it ensures the train being late. If a train needs 40 minutes running time and 5 minutes dwell time, then the schedule should be not less than 45 minutes.

Passenger Train Meets:

Beyond the three basic scheduling components -- pure running time, dwell time, and recovery time -- certain other allowances are necessary for proper scheduling. This includes passenger train meets. When such meets occur on single track, time is factored into the schedule to accommodate the meet. Which train will take siding will vary from day to day; and if the trains have equal priority, not even a crystal ball will predict a day in advance where the meet will occur or which train will take siding. Since 76 percent of the Amtrak system operations are in traffic control territory (TCS), the practice is to add 5 minutes additional recovery time to each train for the meet. While this becomes a windfall for the train holding the main track, provided it has clear signals, it mitigates the impact upon the train taking siding; the balance of the delay, if any, is covered by recovery time. Amtrak may request that some trains, especially those running toward critical connections with other passenger trains, be given priority in meets with their counterparts in the opposite direction.

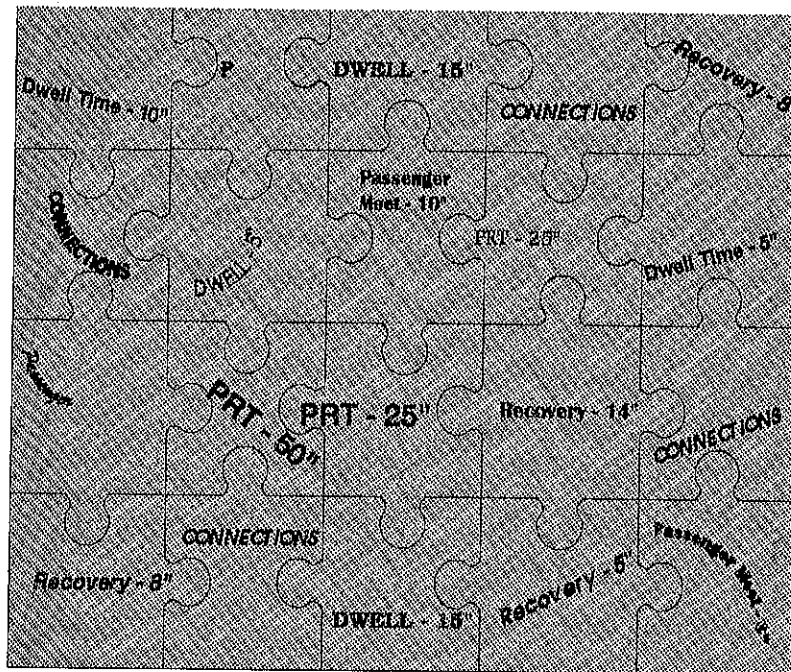
Other Scheduling Considerations:

Each train may encounter certain conditions peculiar to that or unique to that train which may require special consideration in building a schedule. One example is Customs and Immigration delay, which, technically, is dwell time, and which occurs at different stations depending upon the direction of the train.

Probably, the most unusual example is the inclusion of the 5 extra minutes in the schedule of Train 3 to stop and cool traction motors at the summit of Raton Pass in Colorado (one direction only), as the ascending grade at 3 1/2 percent is the steepest grade on the Amtrak system.

Examples such as the ones cited above are rare; therefore, this discussion on schedule construction will be limited to pure running time, dwell time and recovery time, plus passenger train meets.

Schedule Stringing:



Now that the pure running time and dwell time requirements have been identified and the appropriate amount of recovery time determined, what will be done with it? The analogy of putting together a jigsaw puzzle is very close to the task of developing a schedule.

The critical skill is stringing the schedule. This means putting the time together in a meaningful way that permits the train to operate, generally without "killing time"² and yet reasonably close to one time. This is "the art of scheduling."

Proper stringing of the schedule is critical because it plays a significant role in whether the train operates on time or late. It is also important to maintain on-time

² Waiting for scheduled departure time at a station or running slow in advance of a station.

performance at en route stations. When all the recovery time is bunched at the end point, the train becomes later and later en route as delays occur, but it arrives at its end point on-time or ahead of time. This is a disservice to all passengers entraining or detraining en route, which is often the overwhelming preponderance of the passengers, but it does help performance statistics and is the preferred methodology of freight railroads. In one extreme case on a long-distance train, the train could be 45 minutes late at the next to last station and ahead of time at its final station. This has since been corrected, but must be continually watched to avoid a recurrence.

Pure running times and dwell times are essentially a given, so the real variable is recovery time and how it is distributed. This discussion previously touched upon negative recovery time and took the position that it is not a good practice because it guarantees a late train in order to "preserve" recovery time for later use. Clearly, it is desirable to keep the schedule times "tight" (but not negative) at the first and second stations on a segment to avoid killing time which may be needed later. A well-strung schedule will be scheduled tight at the first one or two stations but will then distribute one-third to one-half of the recovery time before the intermediate contract railroad incentive checkpoint(s) or the end point. There is no ironclad rule to stringing recovery time; good judgment must be exercised.

What about killing time, which often is perceived as being evil. It is not bad in moderation, for example, one or two minutes. It only means the train is on-time. However, it would not be desirable to have a schedule where the train would kill time at

every station. That would be a bad schedule, and inordinately long. Killing excess amounts of time, say five or ten minutes or more on a regular basis, is also a bad practice and should be corrected through restringing, except at key stations where switching or major servicing is performed. Remember, a well-strung schedule materially contributes to a good operation.

As previously mentioned, an allowance should be made for passenger train meets that occur on single track. That allowance, which is actually additional recovery time, should be built into the schedule one or even two stations beyond the scheduled meeting point in the event that if one or the other train is late and the meet does not occur at the intended siding, the recovery time is not wasted by killing time prior to where the meet actually takes place.

On the following page are examples of poorly strung and properly strung schedules.

SCHEDULE STRINGING EXAMPLES

Pure Running Time	Dwell Time	Station	Poorly Strung Schedule "A"		Poorly Strung Schedule "B"		Properly Strung Schedule "C"	
			AM	RT	AM	RT	AM	RT
45"		A	1000		1000		1000	
35"	5"	B	1045	-5"	1055	5"	1050	0"
50"	3"	C	1120	-3"	1135	2"	1130	2"
75"	1"	D	1205	-6"	1230	4"	1223	2"
40"	4"	E	115	-9"	155	6"	145	3"
20"	2"	F	157	0"	245	3"	230	3"
		G	303	46"	303	3"	303	13"
265"	15"		PM		PM		PM	

8% = 23" Recovery Time (RT)

In Example A the schedule is strung too tight, with negative running times, or with no allowance for dwell times. As a result, the train is guaranteed to be late at all intermediate points, getting later and later from station to station until the end point is reached where all the recovery time is buried.

In Example B the schedule is strung using too much recovery time at the front end which may necessitate waiting for time at the first station and subsequent stations and running out of recovery time by the last station.

In Example C the properly strung schedule is tight to the first and second stations, has a moderate distribution of recovery time en route and preserves just over half of the recovery time at the end point. This is a schedule that with good dispatching practices, can be reasonably adhered to.

Summary:

“WHEN THE AMOUNT OF DELAY EXCEEDS THE AVAILABLE RECOVERY TIME, THE TRAIN IS LATE.” A well strung schedule will distribute the recovery time judiciously and will avoid extreme bunching of the recovery at the endpoint.

String Graphs:

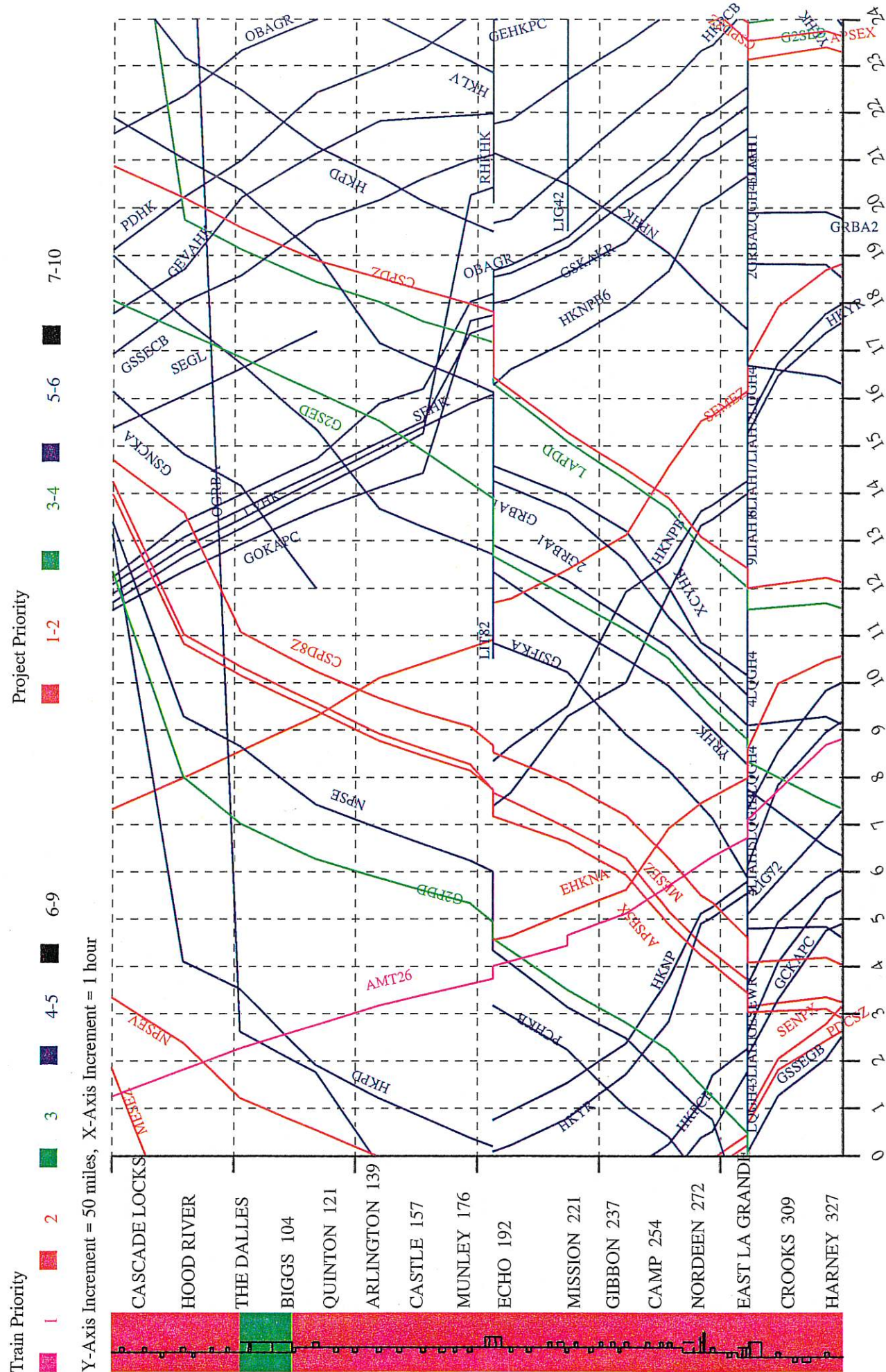
Once schedules for a single-track railroad have been strung, it is a good practice to prepare a string graph. A string graph has time on one axis and stations or mileposts on the other axis. It is a graph of the operation. Some countries use string graphs as their official operating timetables.

The term "string graph" comes from a large panel used over 100 years ago to graph the trains with yarn. The original intent of a string graph was to avoid "cornfield meets" (head-on collisions). Today, it is used to determine if there is a siding available to facilitate meets, to identify passing locations, and to identify and avoid congestion points. When lines cross on a string graph, it is a meet between opposing trains or a faster train overtaking a slower train.

With modern day technology, computers are capable of preparing complicated string graphs. This procedure is currently used throughout the industry. There are a number of different systems in use. Amtrak uses PROTIM, which is a series of programs and databases developed by British rail Business Systems. This system has the capability of developing schedules, station reports and string graphs with extreme accuracy. It is in use on Amtrak's Northeast Corridor, where some segments handle over 300 trains each weekday. The illustrations on the following pages are a computer generated string graph for the Union Pacific in Oregon and Idaho.

TTMS - STRING GRAPH AND STICK MAP

HISTORY DATA - GRANGER TO PORTLAND - 21 JAN 1996, SUN



TTMS - STRING GRAPH AND STICK MAP

HISTORY DATA - GRANGER TO PORTLAND - 21 JAN 1996, SUN

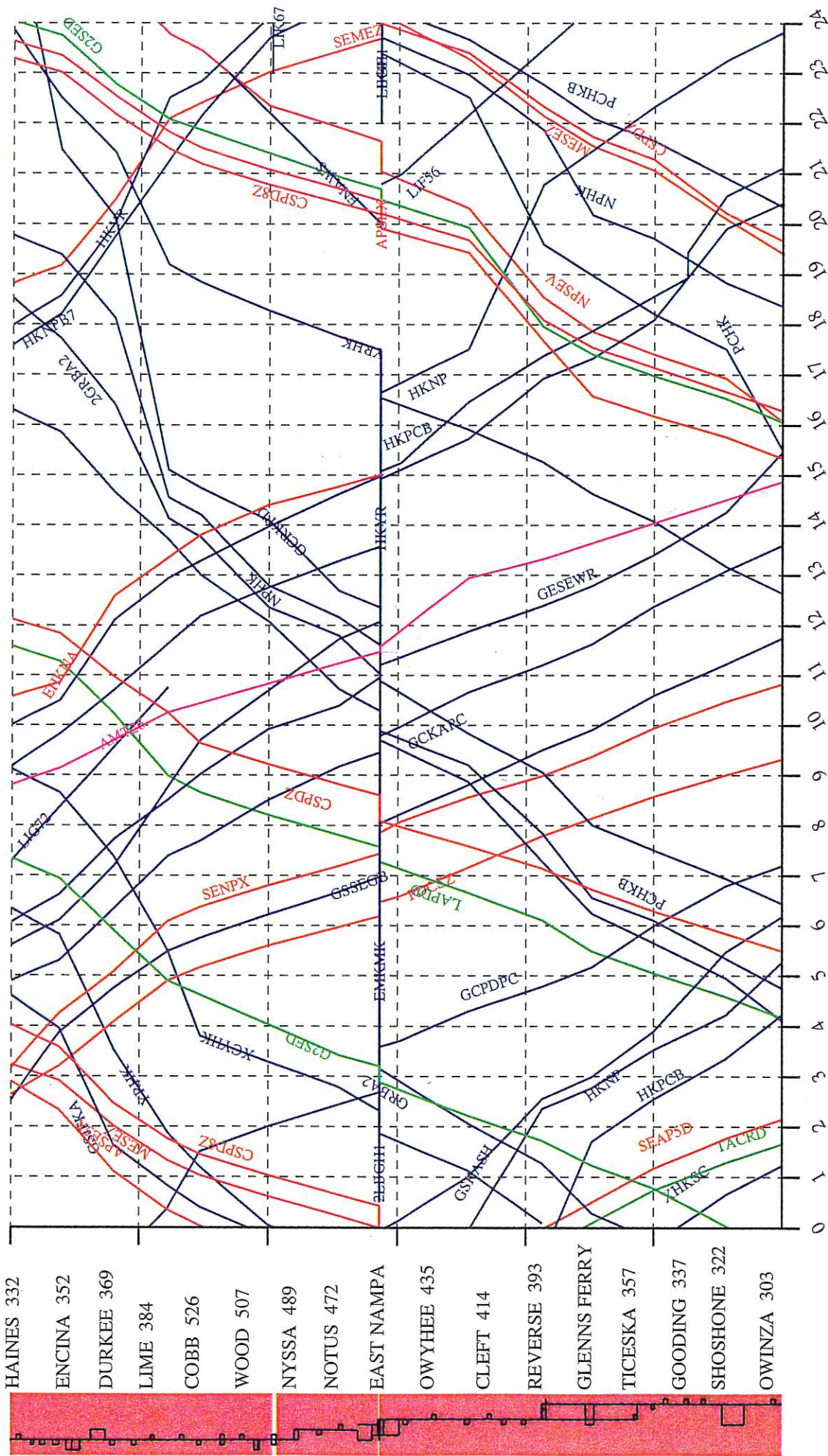
Train Priority



Project Priority



Y-Axis Increment = 50 miles, X-Axis Increment = 1 hour



Connectivity:

Amtrak's entire system is a grid with connections generating a significant portion of the corporation's revenue. Some trains may have a significant number of passengers connecting to another train. There are many connecting points, but Chicago is the real hub of the Amtrak system. Sometimes an adjustment in one schedule will require a similar adjustment in a connecting schedule.

Negotiations:

Many people do not realize that Amtrak's schedules are negotiated with the railroads over which Amtrak trains operate. As noted at the beginning of this paper when Amtrak inherited the passenger train schedules in the early 1970's, some schedules were good, some schedules were bad and some overall were okay but needed restringing. Starting in 1976, Amtrak made a concerted effort to bring reasonable uniformity to the schedules in use throughout the system, but this is an ongoing process that demands time and personnel to stay in tune with operational changes.

Railroads are sensitive to schedules for two reasons: (1) they do not want passenger trains to interfere with their primary freight operations, and (2) on-time performance may drive millions of dollars in incentive payments. Both the length of schedules and schedule times are negotiated.

Railroads are sensitive to schedules for two reasons: (1) they do not want passenger trains to interfere with their primary freight operations, and (2) on-time performance may drive millions of dollars in incentive payments. Both the length of schedules and schedule times are negotiated.

Another critical factor is scheduling of commuter trains and intercity passenger trains so that conflicts are minimal. This is called slotting trains. Commuter trains and intercity trains may operate on three-minute headways, and passing locations are critical between express trains and local trains making all stops. In like manner, meeting opposing commuter trains is also a critical element.

The negotiation of schedules is as important as all other aspects of scheduling.

PART II

THE IMPACT OF DELAYS

The Impact of Delays

After consideration of all the factors essential to proper schedule construction, why don't trains run on time? The missing element is delay. Some delays are covered by recovery time; some are not. The causes of delays could fall into hundreds of categories, which in Amtrak's performance reporting system have generally been condensed into ten, plus "miscellaneous," which is a catch-all.

**When the amount of delay exceeds the available recovery time,
the train is late.**

Some delays are considered to be under Amtrak's control, such as:

- Mechanical failures
- Servicing delays
- Passenger related delays, the preponderance of which are excess station dwell times. This is a category of delay that must be carefully monitored by field supervision due to the tendency of dwell time delays increasing over a period of time.

Some delays are considered under the freight railroads' control:

- Freight train interference
- Signal delays
- Maintenance-of-way/slow order delays

Some delays are beyond the control of either organization:

- Firehoses over the tracks
- Snowslides, rockslides
- Heat orders, cold orders
- Grade crossing or trespasser accidents
- Vandalism
- 1,000 other things

These types of delays are known generally as "third-party" delays.

Some of the more bizarre delays Amtrak has experienced include striking and killing a buffalo in North Dakota, a World War II mine washing up on the shore of Puget Sound, and extracting an obese passenger from the toilet of the Broadway Limited.

Freight railroad causal factors generally account for 40 to 50 percent of the total delays -- while Amtrak-related delays generally account for 20 to 30 percent and all other delays for the remaining 20 to 30 percent

Signal Delays:

The frequency of signal delays closely follows freight train interference and is often the result of the signals working as intended because of a train ahead, as opposed to a true signal system failure.

It would be desirable to divide signal related delays into two sub-categories, i.e., working as intended or a signal failure. However accurate information is frequently not available until later and it would be difficult to segregate this information. When a signal is at "stop" because there is a freight train ahead, it should not be reported as a signal failure, it is freight train interference. Unfortunately, a crew delay report reading "Ajax, 10 minutes, red signal" will be reported by the person entering the data into the system as simply a signal delay for lack of any better information.

Slow Order Delays:

In like manner, maintenance-of-way/slow order delays are very significant delay factors and fall into two major categories:

The first is slow orders because of deteriorating track.

The second is slow orders or work orders because of routine maintenance or rehabilitation of track. Modern maintenance practices with production gangs frequently require taking the track out of service, or require slow orders and lookout orders which impact upon performance. However, just as in the case of signal delays, it would be desirable to sub-divide this category between slow orders due to track conditions and slow orders due to maintenance-of-way work. This should be easier to quantify and segregate than signal delays. However, train crews, and thus their delay reports, may not know or specify the causal factor of any given slow order.

Seasonal Schedules:

The issue of maintenance of way delays raises the question of whether train schedules should be modified to provide summer schedules (as opposed to winter schedules) to compensate for delays expected to result from major maintenance projects. The answer to this is clearly "yes" if the maintenance project will be of

sufficient duration to have a significant impact upon on-time performance. As new maintenance procedures have evolved with the use of large production gangs that take a segment of track out of service, and with the difficulties and production loss associated with clearing to allow a train or trains to pass, it is important to coordinate train operations and maintenance programs to minimize delays and to maximize productivity.

A more fundamental question is whether circumstances justify summer and winter schedules for more than just maintenance-of-way work; for example, ski resort travel that exists only in winter or other seasonal requirements, such as variance in station dwell time requirements.

Coordinating Maintenance Projects With Train Schedules:

Maintenance operations usually have a twelve-month window in the southern half of the United States, while the same work must be compressed into an engineering season, generally April to November, in the northern half of the States. Timetables generally change in early April and late October, which provides a nearly seven-month summer schedule and a slightly over five-month winter schedule. If a major 30-day maintenance-of-way project is going to occur, it is probably not practical to amend a schedule for seven months because of one month of impact. However, if a 90-day project is scheduled, a temporary schedule for that train, say June 1 to August 30, is

preferable to operating the train late every day or four or five days per week until the project is completed.

Coordinating maintenance-of-way projects with train operations is a relatively new concept that has not reached its full potential. Adjusting maintenance-of-way starting times or working night schedules may materially reduce potential delays; however it is equally important once this has been done to keep trains on time to protect or honor that window to minimize any maintenance-of-way delays as well as delays to the workforces.

There is frequently resistance to operating around or bussing around a major maintenance-of-way program. However it is often better to disrupt operations for a short period of time and let the work be promptly completed than to prolong the work and the delays resulting from a lengthy program.

Engineering Practices, Schedules, and Delays:

Since maintenance-of-way/slow order delays are a major factor in on-time performance, over the years there have been a number of poor practices that actually increase the amount of delay unnecessarily and which, if monitored judiciously, could significantly reduce delays.

Minimizing Delays Resulting From Maintenance-of-Way Practices:

1. Point restrictions (i.e., road crossing at MP 508.0 or bridge at MP 475.5) should be just that; however, we frequently find restrictions one mile either side of the point which results in a two mile restriction.
2. Frequently T&S restrictions will be imposed for several miles or for the entire length of the project even though the track has not been disturbed. Keeping the limits as short as possible and progressing as the work is done will minimize delays.
3. When slow orders result in a lower class of track, some carriers fail to recognize the passenger train speed differential (i.e., Class I: 10 mph freight, 15 mph passenger; Class II: 25 mph freight, 30 mph passenger).
4. Low speed rock and roll restrictions are not applicable to passenger equipment. Therefore, a 15 or 20 mph speed limit prohibition should not apply to passenger trains.
5. Failure to promptly lift restrictions once the condition is corrected unnecessarily delays trains. This is the result of either the M of W employee not notifying the dispatcher, or the dispatcher not promptly annulling the restriction.

6. Failure to properly place M of W flags will adversely affect the operation, as will a failure to properly remove the flags when work is completed.

Frequently, the failure to place flags for slow orders has resulted in excessive delays.

7. Where speed restrictions apply while passing M of W gangs, the foreman may let the restriction apply throughout the entire work limits even though the gang has been passed or is working in one reasonably compact area.

8. When a significant or lengthy restriction applies on one main track, dispatchers may overlook crossing the trains over to an adjacent main track in traffic control territory to avoid the restriction and minimize delay when conditions permit. Dispatchers need to be much more sensitive to these delays.

9. In many cases there is a reluctance to go to 3-inch unbalanced curve speeds as it allows no tolerance. A waiver authorizing 4-inches will provide tolerance to go to a full 3-inches.

10. A series of curves may not be satisfactory for 35 mph in accordance with the FRA track safety standards, so they are restricted to 30 mph whereas an odd speed such as 33 mph would minimize delay. On one carrier, increasing the speed to 27 or 28 mph saved nearly 20 minutes. The slower the speed the more

significant the time savings. Using odd speeds (other than ending with 5 or 0) can result in improved performance.

11. Heat orders are necessary when the ambient temperature exceeds certain predetermined limits. However, issuing heat orders the day before (i.e., 10:00 a.m. until 8:00 p.m.) even though the ambient temperature during those times is not known or equally as bad when the dispatcher fails to annul the restriction once the condition no longer exists, can result in significant delays. In one extreme case, a cold front with a cold rain moved through the area and even though the crew notified the dispatcher, nothing was done to remove the heat order.

All of the above points are the result of some actual experiences which have been encountered during Amtrak's riding programs. While not all of the above delays have occurred on all carriers, those railroads which actively police their properties to avoid such occurrences have not only benefited in minimizing delays to passenger trains and improving their incentive payments, but have also materially reduced delays to their freight operations. Unless a program is maintained to constantly monitor the operations, delays of the types listed above will occur.

There is actually a third category of maintenance-of-way delay that does not generally get recorded as a delay. Examples of this category include a long-standing slow order that eventually gets moved to a more permanent bulletin and, when no one is looking, slips from a bulletin into the new timetable and becomes a permanent restriction. A similar example is skimming some superelevation out of a series of curves and then through the same process slowing down the railroad -- a few miles at first, then a few more, until a hundred or more miles have been slowed down. Once the reduced speeds are entered into the timetable they are no longer reported as delay; however the overall impact is that they erode recovery time, until there are sufficient speed reductions which may result in trains running late. It can also result in thousands of minutes of delay each year that are not reported as delays. This practice is usually in violation of a carrier's contractual obligation to Amtrak, but restoration of speeds or other speed increases to compensate for the reduced speeds is difficult at best. This practice is analogous to taking a few cents out of the till each day, then a dollar or two, that nobody misses until an audit is performed. Delays are seldom reported in this area until a train cannot make its schedule. Sometimes this will be reported as a "running time" delay.

Passenger Train Meets:

The next major delay category is passenger trains or what is referred to as passenger train interference. This is the delay that occurs to one or both trains when two passenger trains meet. Freight railroads charge these delays against Amtrak since,

but for the presence of a second passenger train, the delay would not have occurred. Amtrak charges these delays against the railroad, since train dispatching is performed by the railroad and time is allowed in the schedules to compensate for the meets.

While the responsibility for the delay may never be resolved, this becomes a stand-alone delay category over which reasonable control exists through good dispatching practices. On some lines where several pairs of passenger trains operate on single track, such as the San Diego Line or the San Joaquin Valley line, passenger train meets may be a leading cause of delay. Under these circumstances, one late train may cause the "domino effect," delaying the opposing trains that it is scheduled to meet. They in turn delay the opposing trains they are scheduled to meet. All this results from being at the wrong place at the wrong time. This raises the issue of "out of slot."

Out of Slot- A Myth or For Real?

There is a long-standing theory within the industry of the impact of a train being out of slot. The theory is that a train that is on-time is easier to keep on-time than it is for a late train to avoid becoming later.

It appears to be a fairly universal theory, or at least a perception, that once a train becomes late it is more difficult to keep on time than when it is on schedule.

However, even if this is true on dark (unsignalled) rail lines or perhaps in train order ABS (track warrant) territory, the very nature of a traffic control system (TCS) would mitigate against this being true in TCS territory.

For example, being late in TCS territory may simply move the meet from one controlled siding to another without material impact. It should be kept in mind that the degree to which scheduled freight trains actually adhere to their schedules is also a significant variable. Passenger train meets at locations other than the programmed siding may or may not have a negative impact upon one or both trains.

There are some out of slot factors that do have a direct impact upon a train getting later without regard to TCS territory -- for example, commuter trains where a late train may take multiple hits, or maintenance-of-way work or programmed work that would have been avoided if the train had been on time. In like manner, opposing or following fleets of freight trains could have an impact. Conversely, a late train might also avoid such delays by virtue of the fact that it is late, so the impact of being late cuts both ways.

As a result of these discussions, a study was conducted on whether the out of slot theory has any statistical merit in today's operation.¹

¹ See paper entitled "Out of Slot -- Fact or Myth," dated January 2, 1996.

The study addressed the performance of nearly 600 trains over seven railroads and totaled in excess of 500,000 train miles. The current Amtrak route system mileage includes approximately 3 percent which is unsignalled, 21 percent with an Automatic Block Signal System, and 76 percent with a Traffic Control System. Only 4 percent of the route mileage is over rail lines with both commuter and intercity passenger trains.

The study recognized that "out of slot" may be a problem in certain limited applications such as in a joint commuter/intercity operation.

The end result of that study was a conclusion that in today's operation the out of slot theory, except in limited applications such as stated above, is generally a myth. The percentage of on-time trains or late trains losing more time was not materially different, while late trains lost slightly less time than on-time trains. Whether the theory was ever more than a perception -- as opposed to having statistical validity -- cannot be proven since records no longer exist to substantiate the theory. One unexpected by-product of the study showed that trains are generally not abandoned from a dispatching standpoint once they become late.

Heat Orders and Cold Orders:

The use of heat orders and cold orders has grown significantly over recent years. The practice has considerable merit from an engineering standpoint, as it reduces stresses to the track structure during periods of extreme temperatures -- generally

ambient temperatures above 95 degrees F or below zero degrees F. Some carriers place heat or cold orders when there are extreme temperature changes within a prescribed period of time. Inconsistency is where the difficulty occurs. Generally, there is no standard practice, throughout the industry, either on when to apply such restrictions, or on the severity of such restrictions. Some carriers watch ambient temperatures carefully, place restrictions only when the temperature threshold is exceeded, and promptly remove restrictions when they no longer apply. Other carriers are not as precise. One carrier will issue a bulletin at midnight restricting train speeds from 10:00 a.m. until 8:00 p.m. the following day or days. Other carriers are responsive to placing the restrictions, but lax in removing them. On one carrier a long distance train was restricted by a heat order. A cold front passed through and the crew reported a cold rain to the dispatcher, who refused to annul the restriction, and the train received an unnecessary hour of delay.

Another issue is how such restrictions should be categorized. There are arguments that say they should be charged as maintenance-of-way delays, or weather related, or miscellaneous. Currently, they are generally captured as weather-related delays.

Avoidable Amtrak-Related Delays:

Another type of delay related to dwell time, but which often occurs under the cover of darkness and is probably underreported, is what is referred to as the "Grey

Poupon Syndrome." This occurs when two passenger trains meet on the road between stations and stop to hand off provisions to each other. These may include sheets or pillowcases, marinara sauce or Grey Poupon mustard and an occasional carryby passenger. This is not an accepted practice, but when it does occur it should be reported as a delay.

Similarly, the practice of "streetcarring" passengers, i.e., collecting tickets one at a time on the platform, which results in delay to the train, is not an acceptable practice and is probably never reported as a delay, but appears as excess dwell time and finally as a "passenger related" delay. This is a difficult delay to quantify -- i.e., what would the delay have been if normal boarding practices had occurred? Generally, it amounts to the number of minutes in excess of scheduled dwell time.

Killing Time:

Finally comes the question of "killing time" -- Is it a delay? The answer is "yes" it is a delay, but it is a good delay when used in moderation because it means the train is on time. Killing time comes in two forms. The first is running somewhat slower to avoid arriving at the next station too far ahead of scheduled departure time. The second is sitting at a station when the work is completed, waiting for the scheduled time to depart.

In any riding program it is essential to capture this time and record it as a delay. Killing one or two minutes is not evil; however when five or ten or more minutes are

frequently killed, it is a sign that the schedule needs to be restrung and the time used elsewhere where it will be more beneficial.

Late Connections:

This discussion addresses whether late connections are really a delay or whether they represent a duplicate counting of an accumulation of other delays.

Late connections are a delay en route if a train is held for a connecting train or bus. For example, Trains 8 and 28 connect at Spokane and Trains 92 and 82 are joined at Jacksonville, as are Trains 49 and 449 at Rensselaer. If a train is held for the other train, it is late-connection delay. Another example is in the San Joaquin Valley of California, where numerous busses connect with each train. Again, if a train is held at a point for a bus connection, it is a delay.

Conversely, if Carrier A delivers a train late each day to Carrier B at Denver, it is not a "delay" that occurs on Carrier B. It is a result of delays which actually occurred and are already accounted for on Carrier A. Another example: if a train is held in Chicago for connecting trains, it is late but it is not a delay that occurred on the carrier that received the train late.

The question may be raised, "So what? What difference does it make?" The answer lies in the example shown above at Denver. Carrier B reported thousands of

minutes of delay on late connections -- so many thousands of minutes, which did not occur on their railroad, that the statistics of what really happened on Carrier B were obscured by delays that actually occurred somewhere else. Carrier B used this as a subterfuge to obscure their own shortcomings. This type of obfuscation eventually led Amtrak to conduct the "out of slot" study described earlier, which showed that a late connection did not make a material difference in the train's performance. In the case of Carrier B, the late train did impact upon maintenance-of-way forces the next day but not on the overall performance of the train.

Just as some carriers may abuse or overreport late-connection delays, some conductors may enter "late arrival" as a delay on their delay reports just because the train arrives late at an intermediate crew-change point. However, the late arrival was caused by delays that already occurred on previous crew districts, and as such should have been accounted for by those previous crews.

Selective Delay Reporting:

Selective delay reporting is an old railroad practice of reporting only enough delay to cover the amount of time lost on schedule. This was generally done in the dispatcher's office. Does anyone recall seeing a delay reading "Ajax, 20 minutes, bad meet"? Not really. Perhaps "Ajax, 20 minutes, inspection," or "hard throwing switch" or "signal would not clear," but not a "bad meet."

Since all trains have recovery time, a train is not late until the amount of delay exceeds available recovery time. For example, if a train has 20 minutes available recovery time over a segment, it would generally (but not always), need 40 minutes of delay to be 20 minutes late. Selective delay reporting gave the dispatcher the opportunity to "select" which delays they would report to cover the 20 minutes of time lost on schedule.

The primary disadvantage of selective delay reporting was that only a portion of the delay was reported, so when it came to analyzing or identifying the problem areas the delay reports were worthless. Amtrak believes that all carriers have dropped this practice. It is essential to know where all the delays occur so that the problem areas that need to be addressed can be identified.

Today the Conductor's Delay Report is the document that Amtrak and most carriers recognize as the "official" delay report. Amtrak and one of the carriers conducted a detailed study in 1994 to evaluate delay reporting. The Conductor's Reports and dispatching reports were each compared to the actual delays as observed in the field by the study participants. It was concluded that the Conductor's Report was by far the more reliable document.

Train Dispatching:

The key to the performance of the trains rests with the train dispatcher.

Sometimes the dispatcher is faced with several different choices, such as:

Which train gets preference?
• No. 199 with the its intermodal trailers and containers • LABRF with its hot manifest • Madame X -- the division cleanup train • The Night Crawler - a puller handling empty camp cars • The Dogpatch Local - with two empty cars for the mill • Yard engine - going to the beanery to eat or switching the car repair tracks • All of the above
OR
• Passenger trains

What it all boils down to is the quality of train dispatching. The train dispatcher generally responds to the policies established by senior management. Which train gets the priority is the railroad's call.

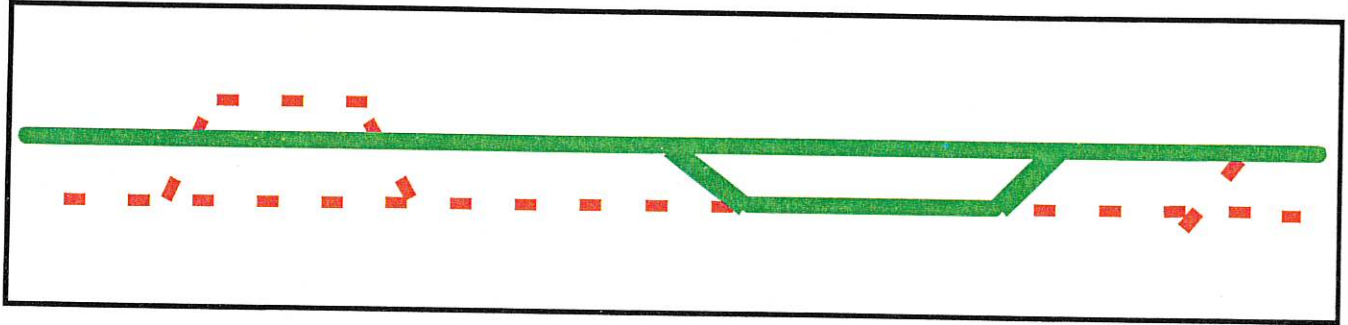
The policy varies significantly from one carrier to another. One key element is that passenger trains have priority over freight trains by statute, under the Rail

Passenger Service Act. All railroads profess to give passenger trains priority, but it just doesn't always happen. Statutory preference does not mean that passenger trains must always hold the main track at meeting points. On the contrary, in traffic control territory, the passenger train taking siding for a fast freight may expedite the meet and minimize the delay to both trains.

Computer Aided Dispatching or CAD (which perhaps should actually be known as Dispatcher Aided Computers) permits the computer to dispatch trains -- just plug in the priorities and watch them roll. Well, sort of. The computer can make some bad decisions unless the dispatcher catches the error and overrides the decision. Some dispatcher's territories are analogous to the old television skit of the one-man cake factory where cakes spew off a conveyor belt until chaos reigns. Conversely, where train dispatching territories have not been consolidated and expanded to the point where only the computer can dispatch the overall territory, CAD can be a valuable aid.

Software experts continually refine programs to correct situations where trains take siding with no train to meet -- known as meeting ghost trains -- or the local freight receives priority over the hottest train on the division. One thing generally agreed upon by all is that CAD-generated delay reports are for the most part worthless. Conversely, dispatchers can override the system and sometimes set up a situation that may negatively impact priority trains. It is a delicate balance.

Rationalization:



Rationalization, a buzzword of the 1980's and 90's, means reducing the physical plant to the maximum extent possible, often without regard to potential increases in traffic. It comes in two forms. The first is where mergers result in generally parallel routes. One is downgraded and the other becomes the primary line with resulting traffic increases. The second, which is actually more common, is where a conversion is made from two main tracks to single track. Sidings or main tracks are removed and the resulting plant has less capacity.

The situation is made worse if the segments of single track are made too long, if sidings or leftover segments of double track are made too short to enable "running meets" wherein neither opposing train has to stop for the other, or if sidings are left unsignalled or slow speed turnouts are installed, requiring trains to crawl into the sidings at slow speed. All of these "short-cuts" may lessen the initial cost of the single-tracking project or increase short-term savings, but by creating a less-fluid main line, they lower overall capacity and increase long-term costs and delays.

The increase in traffic over the past several years has left many railroad management scratching their heads about how to increase capacity quickly and economically. Some carriers with critical choke points are now hurting in trying to expedite freight traffic in addition to passenger trains. Threading a passenger train through congested areas is a difficult task.

Summary:

Finally, there is a logical question: If the train runs late every day, why not add time to fix it? There are three basic reasons:

- 1) If there is excess time in the schedule the train dispatchers tend to take liberties with the trains.
- 2) Station work tends to expand to fill all available time.
- 3) If a schedule is basically adequate and a train runs 30 minutes late each day and 30 minutes is simply added to the schedule, in 90 days it will be running 30 minutes late each day. It is essential to fix the basic problem.

The opening comments stated that a train with too much time in the schedule will run late. The reason for this is that the first dispatcher will put the passenger train in the siding and advance a freight train, thus causing, for example, 25 minutes delay, and

using the rationale that there is an abundance of time in the schedule to make up the delay. The second dispatcher's rationale is "I got the train 25 minutes late and I delivered it 25 minutes late. I broke even with no delay to report." The third dispatcher says: "Damn, every day I get the train late and they expect me to make it up." And so the train runs late. In many instances, implementing faster schedules has actually improved performance.

A well strung schedule with a reasonable amount of recovery time is the first step to improve performance. The second step is receiving the appropriate priority and a commitment from the carrier to maintain good on-time performance. The third step is good train dispatching.

A sufficient amount of recovery time is very important. Several years ago, the schedule of a long-distance train on one carrier was tightened up so much that almost all recovery time was removed. The dispatchers discovered that no matter how hard they tried they could not reliably keep the train on time. Soon they gave up and began giving priority to freight trains. After the real problem of insufficient recovery time was identified and after recovery time was added back into the schedule, dispatching and on-time performance both improved dramatically.

But excess time in the schedule can be a performance killer. One on carrier, 30 minutes was added to the schedules of four trains to compensate for a major engineering project. On-time performance improved substantially. However, once the

project was completed, performance dropped as the excess time was used for flagrant freight train interference which far exceeded the additional 30 minutes. On another carrier, it was pointed out that delays were occurring because the two passenger trains met on a single track and that with only a one-hour adjustment, the meet could be moved to double track. This was done, but the performance did not improve. Passenger train interference dropped significantly, but freight train interference increased dramatically.

Fortunately, the examples in the preceding paragraph are atypical for the industry. There is a concerted effort being made between carriers and Amtrak to improve on-time performance, to identify and evaluate operating problems, and to better control the delays that are controllable.

Scheduling Trains: A Summary

Scheduling has three basic components and an important secondary factor:

- Pure running time
- Dwell time
- Recovery time
- Passenger train meets

Once the above data are known:

- The schedule is strung.
- It is checked on a string graph.

Connections are a critical part of scheduling

Once proposed schedules are developed they are negotiated with the freight railroads:

- Schedule times
- Length of schedules

When delay time exceeds recovery time, the train is late.

Delays are measured in broad categories:

- Amtrak related delays
- Freight carrier related delays
- Passenger train meets
- Delays beyond control of either party

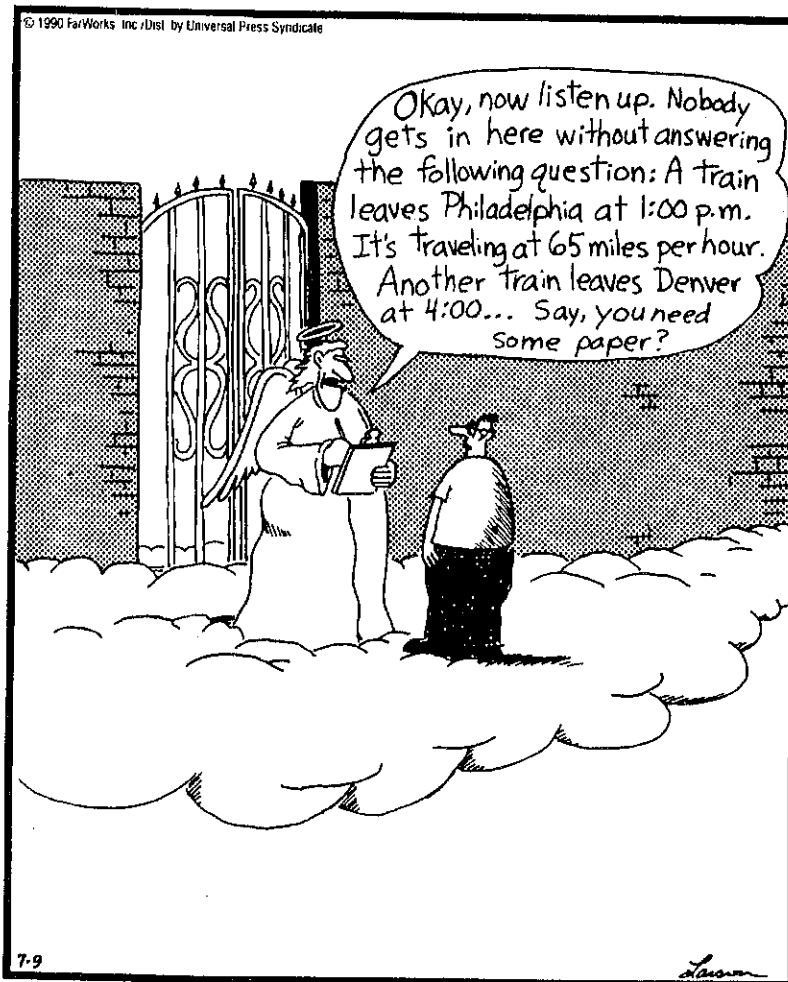
Control is vested in the train dispatcher, who governs priorities consistent with corporate policy. The dispatcher has the ultimate control.

Schedules must be coordinated with both freight and commuter operations.

Schedules impact upon the carriers' ability to earn millions of dollars in incentives.

THE FAR SIDE

By GARY LARSON



Math phobic's nightmare

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PART III

**THE ART OF
SCHEDULE ANALYSIS**

Background:

When Amtrak assumed responsibility for the operation of Intercity passenger trains in 1971, it inherited the existing schedules of the freight railroads. Some of these schedules were poor, some were good, and some needed restringing. From 1971 until 1974, there was no strong working relationship between Amtrak and the railroads that addressed on-time performance and schedules. As a result, performance deteriorated. In 1974, the first incentive agreements were negotiated with the carriers but little was done to rationalize or improve schedules. Many lessons were learned from those First Amendment Agreements and in 1976, with the advent of the Second Amendment Agreements, refinement and negotiation of schedules became an integral part of the operating agreement and of financial arrangements between Amtrak and the freight railroads.

As a result, the 1976 contract negotiations resulted in the development of the schedule analysis program which, with moderate refinements, is in use today. In 1976, incentive payment potential was tied to the quality of the schedule and appropriate speeds. Since the Third Amendment Agreements of 1980, essentially all long-distance trains have been tied to intermediate point on-time performance. This is measured from A to B, A to C and A to D, etc., with A being the initial point on the railroad. This methodology does not permit a carrier to have a poor operation from A to B and get a fresh start from B to C or from C to D.

The Third Amendment Agreements also contain penalty provisions for poor performance. This is required by the Rail Passenger Service Act. Both the intermediate performance and penalty provisions are critical components of the post-1996 agreements as well.

Performance payments are measured on an individual train basis each month. Incentives are paid if the train operates between 80% and 100% on time. Performance between 70% and 80% does not earn incentives, and performance below 70% incurs penalties at the same rate as incentives are paid above 80%. The penalties are against incentives earned during the previous twelve months.

Incentives are not an insignificant item. The maximum potential for the industry is approximately \$55.5 million per annum. During the five years FY '91 to FY '95 Amtrak paid an average of \$22.5 million per annum. This is not an insignificant amount of money. If Amtrak were a freight shipper and the industry transportation ratio was 80%, it would take approximately \$110 million in gross revenue to produce the same results for the freight railroads. Amtrak encourages the industry to seek incentive payments. The down side of the numbers quoted above is that the industry has only earned approximately 40% of its incentive potential over the past six years. Reasonable diligence in expediting passenger trains should earn 50% of the potential (some carriers earn 80% or more of their potential), which means that approximately \$11 to 22 million is left on the table each year. A critical element of the incentive program is the quality of the schedules.

One final comment on schedule performance and incentives. An order of magnitude on incentive potential on an 1800-mile train would be \$5,400 per trip or \$162,000 in a 30-day month. At 90% on time, it would earn \$81,000 in that month. However, some railroads look at the potential from a different perspective. The first 24 trains must be operated on time before they are "in the money," then each of the remaining 6 trains is worth \$27,000. Their perception that each train lost is money left on the table is absolutely correct.

Why are the incentives such a significant item when it comes to preparing schedules? The answer is, that well strung schedules are critical to on-time performance and therefore play a critical roll in generating incentives.

In our paper on scheduling, we pointed out that with a schedule that has too much time the train will run late, just as a train without sufficient time will run late. The train with too much time is likely to take a beating from the dispatcher because of the excess time and it will frequently run late just as the train with insufficient time.

Remember, there are three basic components to schedule construction. They are:

- 1) Pure Running Time.
- 2) Dwell Time.
- 3) Recovery Time

What might be considered a fourth component is passenger train meets, but that is actually extra time built into the schedule to compensate for the meets.

Pure Running Time is the amount of time required to go from one station to the next, without delay, and is based upon a predetermined power-to-weight ratio.

Dwell Time is the amount of time required at a station to perform station work. In addition to passenger handling it may also include time for mail, baggage or express, crew change, switching, inspection or servicing.

Recovery Time is the amount of time added to the above components to compensate for delays encountered en route. It is generally in the range of 6% to 8% added to the above times.

Remember, when the amount of delay exceeds the available recovery time, the train is late.

The task in analyzing a schedule is to factor out all delays en route and to divide the schedule into the three basic components. The task is not easy but once an individual is familiar with the proper procedure it can be accomplished with amazing accuracy. Frequently, Pure Running Time is calculated over long segments by different

riders with only a fraction of a minute variance in their respective reports between stations or over the entire route.

Objective:

Welcome to the world of schedule evaluation. Once you have completed the classroom instruction and field training with this program, you should be able to divide a schedule into its three basic components:

- Pure Running Time
- Dwell Time
- Recovery Time

In addition, you should be able to quantify delays by causal factors and determine the percentage of recovery time. A final check is determining how well the train was handled consistent with the rules and applicable speed restrictions. Remember, the purpose of this program is to effectively analyze schedules, not to perform crew evaluations.

Preparation:

Life all night on an engine can be a grueling experience, especially riding the jump seat on an F40. There is much you can do prior to the trip to make life considerably easier during the evaluation; however, there is nothing you can do to make life easier on the jump seat except stand up.

On longer trips where two or three team members will participate, the segments each person will check must be determined in advance. At locations where riders are going to change, it is the responsibility of the relieving rider to record the arrival and departure times at the change-off point; however, it is also good practice for the arriving rider to do the same. It is also important for the riders to synchronize their watches before the trip.

If the check is to address operating problems or freight train interference it is best for the dispatcher to be unaware of the riding program. However, there are times when a joint riding program is made to evaluate schedules, it is advisable to inform the dispatcher of the test in order to obtain data with a minimum of delays.

A major portion of the task is quantifying delays; therefore, it is necessary to know the maximum authorized speeds and station locations. This comes from the operating timetable; however, operating timetables of today are not easy to carry, may be only slightly smaller than a telephone book, and frequently require the reader to hop from one page to another as districts or subdivisions change. Therefore, the first tools you need are a scissors and tape to make yourself a customized timetable that follows the route of the train. A sample of the cut and paste (tape) timetable is shown in Exhibit 1. This is an important part of the evaluation.

In addition, it is a good practice to review the Special Instructions and the track charts at the office before you go on the road, especially when you are not familiar with the territory to be evaluated. However, it is not recommended that you carry this information because it is normally too bulky and heavy to carry conveniently. In reviewing the track charts or timetable, watch for equations in Mile Posts.

In addition, you should prepare in advance the Summary Sheet (Trip Report) for the train showing the pertinent information for that train including station stops and checkpoints and current schedule. The rest of the information will be written on the form as the trip progresses. This form is shown as Exhibit 2.

The consist book should be reviewed to determine the normal consist of the train. Sometimes it is necessary to add one or more cars to obtain the proper power to weight ratio for the test, or to hold a deadhead car for movement at a later date in order to maintain the integrity of the test. In like manner the power consist should also match the desired test. This should not be left solely to chance.

EXHIBIT 1

10.0 NAHUNTA SUBDIVISION-NH

MP/ Ctr Pt	↓ SOUTH ↑	STATIONS	SDG CAP (Ft)
A639.4 1441-1442	NS MONCRIEF	Jacksonville (Pasgr Station) 3.1	
A642.5	SANFORD SD	Beaver St.	

50.0 WILDWOOD SUBDIVISION-BL

MP/ Ctr Pt	↓ SOUTH ↑	STATIONS	SDG CAP (Ft)
SP635.1	NAHUNTA SD	Beaver St.	
SP635.2	WEST JAX	3.8 Seminole Connection	
SP639.0 1506	DUVAL	3.8 Carnegie	4003
SP643.9 1506-1509		4.9 Whitehouse	7010
SP652.6 1513		5.7 East Pass	7327
S653.3	BALDWIN YD	6.7 Baldwin Yard	
S655.8 1514	JAX TERM	2.5 Baldwin	
S678.4 1516	No. 1	22.5 Starke	
S680.1 1518	BOOKER SD	1.7 Newman	
S685.1 1519-1520	No. 2	5.0 Hampton	
S690.0 1522-1523		4.9 Waldo	10,290
S696.6 1524-1525		6.8 Orange Height	10,273
S703.3 1526-1527		6.7 Hawthorne	10,214
S712.3 1528-1529	EDGAR SD	1.0 Lochloosa	10,228
S719.8 1530-1531		7.8 Sparr	11,708
S735.3 1532-3.4.4	FM RR	15.5 Ocala	S10,119 N3869
S743.5 1536-1537		5.2 Santos	10,218
S752.0 1538-1539		8.5 Summerfield	10,152
S759.9 1540		7.4 N Wildwood	
S761.2 1542		1.5 Wildwood	
126.1 MILES BEAVER ST. TO WILDWOOD			

13.1 MAXIMUM AUTHORIZED SPEED

Table 4. Maximum Authorized Speed

Between Location/Mile Post	MPH
A506.0, and A638.7	79
A638.7 and A642.5	40

53.1 MAXIMUM AUTHORIZED SPEED

Table 38. Maximum Authorized Speed

Between Location/Mile Post	MPH
Jacksonville and SP635.2	40
SP635.2 and Wildwood	79

53.2 SPEED RESTRICTIONS

Bold MPH denotes city ordinance.

Table 39. Speed Restrictions

Between Location/Mile Post	Psgr. MPH	Other MPH
SP635.0 (A642.5) and SP635.3 (Honeymoon Wye)	15	10
SP635.3 and SP635.5	30	30
SP635.5 and SP639.1	---	45
Beaver Street Tower-Diverging Moves	15	15
SP652.4 and SP653.0	30	30
S653.0 and S653.9	70	---
S670.8 and S672.1	---	60
S678.4 and S679.0	45	45
S690.0 and S690.2	45	45
S690.2 and S690.6	45	45
S704.4 and S705.4	45	45
S709.5 and S710.7	75	---
S731.1 and S731.7	60	60
S731.7 and S733.9	70	60
S733.9 and S734.7	60	60
S734.7 and S736.2	30	30
S736.2 and S740.8	55	55
S745.7 and S747.5	40	40
S747.5 and S750.8	70	---
S760.2 and S760.6	65	60
S760.6 and S761.2	20	20

Table 39. Speed Restrictions

Between Location/Mile Post	Psgr. MPH	Other MPH
Signaled Sidings at Whitehouse, Baldwin, Orange Height, Hawthorne, Sparr, Ocala (Southward Siding), Santos	25	25

EXAMPLE OF SUMMARY SHEET

EXHIBIT 2

Date 2-5-96

TRIP REPORT

Rider JLLTrain 91 Engs. 401-213Consist 9 cars

SCHEDULE	ACTUAL	STATION	SCHED. TIME	ELAPSED TIME	DWELL	DELAYS	PURE- RUNNING TIME	RECOV. TIME
635 Am		Jacksonville						
734 Am		Waldo	59					
819 Am		Ocala	45					
848 Am		Wildwood	29					
926 Am		Dade City	38					
1016 Am		Winter Haven	50					
1057 Am		Sebring	41					
1132 Am		Okeechobee	35					
1235 pm		West Palm Beach	63					
1256 pm		Dalray Beach	21					
115 pm		Deerfield Beach	19					
133 pm		ft Lauderdale	18					

Equipment:

Each person can develop their own equipment kit to suit their own needs; however, certain basic items are essential. First, you need proper footwear, ear plugs, and safety glasses, and always remember that compliance with safety rules and operating rules is essential. For recording purposes you need a pad of paper, pens (at least two colors), a clipboard or something to hold the pad firm, a small flashlight, extra batteries, a calculator, and a reliable watch because you will need to record times to the nearest second. A digital watch makes life much easier, especially while bouncing on the engine in the middle of the night trying to discern whether the minute hand is at 32 or 33. A copy of a previous riding report can also be a valuable aid but is not essential. While a stop watch is recommended by some, you can generally rely on the engine crew to have one or to check the accuracy of the speedometer once you are on the road. You can only carry so much equipment conveniently. Finally, don't forget your headend permit. Crews should ask for it; however, you should always volunteer it.

Now, with this preparation, we are ready to board the engine.

Boarding the Engine:

Boarding the engine is a ritual. Remember, you are invading the sanctum sanctorum of the engine crew. They may eye you with suspicion and wonder "what that (expletive deleted) wants." Introduce yourself and advise the crew that you are doing a schedule check from A to Z and offer them your headend permit. It is important to break the ice at this point so they are comfortable with your presence and understand you are

not there to check their performance. They will ask you a standard line of test questions such as:

1. What do you do for the railroad?
2. How long have you worked for the railroad?
3. What railroad did you work for before you came to Amtrak?
4. Have you ever been on an engine before?
5. Have you ever been over this line before?

The last question is a good one because, if the answer is no, they are most likely prepared to give you an operational guided tour over their railroad.

There are also some key points or questions you want to discuss with them such as:

1. How is the schedule over your segment? This is a good ice breaker as it indicates you are interested in their opinion and you can usually get some good information from them. Some engineers can give you precise information on the operation; others will give you important tips or have recommendations that can improve the schedules. Their recommendations are important.

2. Ask them not to advise the dispatcher that you are there because you want to see what they have to put up with on a normal day. Crews generally appreciate and honor this.¹
3. Request of them that since this a schedule check, they should run as close to the speed limit as they can. This always results in the same answer, "We always do." But in actuality they do not always do that. Your presence may cause them to run 3 mph under the speed limit or perhaps they do this on a regular basis. In any event this destroys the integrity of the schedule check and your efforts and loss of sleep may be for naught. In like manner, speeding destroys the integrity of the check; however, this is seldom, if ever, a problem today.
4. Advise them that if they have to kill time on the road to advise you in advance of slowing down so you can capture the delay.
5. Finally, and most important of all, ask them to review with you all of their restrictions, bulletins and track warrants for work orders, slow orders and other restrictions. These must be recorded in the upper right-hand corner of your work sheet as you will have to watch for them and capture the delay as the schedule check progresses.

¹ As previously mentioned, there may be occasions, such as a joint riding program, where it is desirable for the dispatcher to be aware of the test.

All of the above should be completed before you are on the move, if possible.
Once you are on the move there are two key rules, as follows:

1. Conversation -- Avoid idle conversation to the maximum extent possible.
Don't volunteer any such conversation.
2. Call Signals -- Calling signals doesn't require much effort but it is a good sign to the crew that you are a professional. Most important, it is required by the rules.

Remember, it is perfectly proper while en route to ask questions pertaining to the operation such as: "What is your normal speed here?" or "Do you normally get an Approach Medium signal at this location?" or "Do we have authority to go through Smith's work limits?"

Questions such as "Are you going moose hunting again this year?" or "Do you think the Cubs are going to make it this time?" are superfluous and distracting and are not proper conversations on the headend.

Remember, when engine crews change, thank them for their hospitality and for the information provided. Also remember to brief the relieving crew on items 1 to 5 above.

What Are the En Route Tasks?

The key is to record the operation of the train so you can properly quantify delays or so you can reconstruct the trip at some later date. Depending upon the circumstances, you could even be called to testify from your notes at some future date before a panel or even in court. It is therefore necessary to develop your own style of shorthand. The key is having sufficient information to reconstruct the trip. Writing down the time and speed at every mile post is overkill and is not really necessary; however, more frequent records at first may help you in quantifying delays.

If we are measuring the running time between stations, why is it necessary to write down intermediate mile post times? The answer is that you don't unless the train is going to be delayed, which you cannot always anticipate. However, once a delay occurs you need that time and location to reconstruct the amount of delay.

So what kind of information do I record? There are a number of key elements to record; you can keep as busy as time permits. You must record the arrival and departure times at all stations and key checkpoints. For example, 21st Street Tower in Chicago is a junction between Amtrak and Conrail and the Illinois Central; therefore, the time at that point must always be recorded. Mile Posts are a good point because they represent a finite location that you can always relate to; however, you must always be on guard for equations such as MP 795 follows MP 793 (there is no 794) or where line changes have been made, for example, after MP 793 the next MP is 825. The times at

sidings may be checked at the siding switches or at the station sign. It is a good idea to show all trains met or passed and their locations. On congested lines noting the status of each siding, whether clear or occupied, is a good idea, and all signals that are displaying other than their "normal" indication should be recorded. In addition, where a speedometer is readily available, it is a good idea to record the speed at a mile post when accelerating or when the maximum speed cannot be maintained.

What if I lose my location, how can I tell where I am? Obviously the Mile Post is the best method; however, some Mile Posts are missing, obscured, or may be hard to find. Some carriers, such as the Union Pacific, mark 1/4, 1/2 and 3/4 miles with one, two or three rings around the C&S poles. Beware of signal numbers because the last number is normally not related to tenths of a mile. For example, Signal 962-1 is somewhere between MP 962 and 963 but the 1 may indicate it is a Westward signal, or that it governs Track 1, not that it is located at MP 962.1. Do not try to use signal numbers to measure distances. Numbered control points are generally in relation to mile posts but do not relate to specific mile posts unless the location is identified in the timetable. Finally, if you don't know your precise location, ask the engineer, who will know.

A sample of a worksheet is shown as Exhibit 3. As delays are quantified on the worksheet, they should be circled with a pen of a different color or highlighted with a marking pen, so they can be easily identified. The worksheet becomes the underlying

document for the Summary Sheet (Trip Report). You will be surprised at the amount of information that can be recorded by being diligent and observant in making your notes.

Remember, engineers are professionals and generally take pride in their work. Their input can be valuable. Their estimation of delay is not always accurate and is generally not precise enough for this study, but it can be used as a reality check against your more precise calculations.

EXAMPLE OF WORK SHEET

EXHIBIT 3

No. 91 2-5-96 2 F40s 9 CARS
Engs 401, 263

JLL Weather Clear, Cold (Below Freezing)

RESTRICTIONS

No. 81 Arrd Tax 7:18:38 Left 7:49:55

MP 682.4-690.7 0900 h. Work order

No. 91 doubled to train 8:00:05

MP 682.4-682.5 30 MPH

Wait to complete working mail

MP 683.9-684.1 30 MPH

Air test 8:10:44 Dis. 8:12:57

MP 688.5-686.6 30 MPH

(Blue flag down 8:16:44)

MP 695.5-696.6 60 MPH

Left TAX 8:17:50

MP 704.5-718.7 0830h. Work Order

Beaver Str. 8:24:45

MP 784.6-784.8 25 MPH

W. End Honeymoon Wye 8:25:47

MP 718.1-718.5 25 MPH

Stop { 8:26:38 OBHB Indication
8:30:43 Head Coach

MP 711.3-717.3 25 MPH

MP 638 8:34:28

MP 1003.4-10035 0900-1100 h Work Order

MP 641 8:36:43

MP 1004.8-1007.7 Main Trk 0700 Work Order

MP 650 8:43:28

MP 1012.4-1018.5 0700 h. Work Order

Baldwin 8:45:34

MP 721 10:09:51

MP 660 8:52:44 - Mt. Local 2317N

Ocala { 10:22:23
10:27:05

MP 670 8:59:47

MP 743 10:36:17

MP 676 9:04:17 - Approach Signal

MP 750 10:42:50

MP 679 9:07:28

MP 760 10:50:27

MP 680 9:09:35-43 End of DT

Willowood { 10:53:48
10:54:06 - Bus 7088N

Stop + Proceed at Rest. Speed

MP 681 9:13:23

MP 765 10:59:21

MP 682 9:17:09

MP 770 11:04:20

Clear Sig. 682.5 9:19:19

MP 771 11:05:13

MP 690

Bushnell fl. - App. Med Sig N. end of

Waldo s { 9:28:32
9:32:20

Extra SPB490 Stop at Sig S. end of
Clearing Sdq. Cleared 11:08:52

MP 692 9:34:52

MP 777 11:12:10

MP 695 9:37:14

MP 780 11:14:43

MP 700 9:41:16

MP 788 11:23:02

Stop { 9:44:40 Stop for Inspn.
9:50:44 HBD did not report

MP 790 11:24:57

MP 704 9:51:29

MP 825 11:27:47

MP 713 9:59:21

MP 830 11:32:27

MP 715 10:00:50

Diade City s { 11:33:10
11:33:34

MP 720 10:08:59

N. end Stokes Y125 not in clear X4310

Remember, you started the Summary Sheet (Trip Report) before you left. the Summary Sheet is where you break the schedule into the basic components. This is an important task since the Summary Sheet is the final document that goes into the files and will be used for future schedule evaluation. The Trip Report should be completed (at least for your segment) if possible, while you are en route. First, it is much easier to record the data when it is fresh and you don't have to reconstruct the trip from your notes. Second, it is hard to find time to sit down and reconstruct the trip at a later date. An example of a completed trip report is included as Exhibit 4.

Here are a few points on completing the summary.

Actual Time at stations (and in some instances at key check points) is recorded in the second column from the left. It may be done in seconds, but the arithmetic is easier if it is converted to tenths of a minute. Schedule time is the number of minutes from the departure at one station to the next station, as shown in the current timetable. This column should be filled out in advance of the trip.

Elapsed Time is the number of minutes from the departure at the last station until departure at the next station or arrival at the final station. At en-route stations where both an arrival time and a departure time are shown, such stations are generally shown as a separate entry.

Dwell Time is the number of minutes standing at the station shown, and for second or third spots it is the amount of time from the first stop until the last departure.

Delays are recorded directly from your Work Sheet from one station to the next.

Pure Running Time is elapsed time minus dwell time and delays. For example, on Exhibit 4, the elapsed time between Waldo and Ocala was 54.7 minutes. Pure Running Time was 54.7 less 4.7 minutes dwell and 12.2 minutes of delay or 37.8 minutes.

Recovery Time is the difference between Pure Running Time (PRT) plus Dwell Time and Schedule Time. This number may be negative or positive. Using the above example between Waldo and Ocala, the PRT was 37.8 minutes plus a dwell of 4.7 minutes for a total of 42.5 minutes. Under schedule time you note that 45 minutes is allowed; therefore, the recovery time is a positive 2.5 minutes. The recovery time station to station is recorded in the upper left portion of the recovery time column, while the cumulative recovery time is recorded in the lower right portion. Again, looking at the same example, there is 2.5 minutes recovery time between Waldo and Ocala and 7.6 minutes recovery time between Jacksonville and Ocala. As a second example, look at Deerfield Beach to Ft. Lauderdale. There is a negative 3.6 minutes recovery time between those stations, but there is a positive 37.4 minute recovery time between Jacksonville and Ft. Lauderdale.

As a check on your arithmetic, the bottom lines on your Summary Sheet (Trip Report) should total, PRT plus Dwell Time plus Recovery Time should equal Schedule Time.

SUMMARY SHEET (Trip Report)

EXHIBIT 4

Date 2-5-96

TRIP REPORT

Rider JLL

Train 91 Engs. 401-263

Consist 9 Cars

SCHEDULE	ACTUAL	STATION	SCHED. TIME	ELAPSED TIME	DWELL	DELAYS	PURE-RUNNING TIME	RECOV. TIME
635 Am	8:17:50	Jacksonville	59	74.5	3.8	4.3 Inspd; 4.1 Sig + 5/7.7 Sig,	50.1	5.1 / 5.1
734 Am	9:28:32 9:32:20	Waldo	45	54.7	4.7	4.7 Slow order 7.5 Inspd.	37.8	2.5 / 7.6
819 Am	10:22.4 10:27.1	Ocala	29	27.0	0.3	none	26.7	2.0 / 9.6
848 Am	10:53.8 10:54.1	Wildwood	38	39.5	0.4	Slow order 2.0 0.9 Signal	36.1	1.5 / 11.1
926 Am	11:33.2 11:33.6	Dade City	50	47.3	1.7	3.6 Signals	42.0	2.3 / 17.4
1016 Am	12:18.1 12:20.8	Winter Haven	41	37.6	3.4	none	34.2	3.4 / 20.8
1057 Am	12:55.1 12:58.5	Sebring	35	42.1	0.3	9.2 local freight	31.6	3.1 / 23.9
1132 Am	1:40.3 1:40.6	Okeechobee	63	53.9	3.9	none	50.0	9.1 / 33.0
1235 pm	2:30.6 2:34.5	West Palm Beach	21	40.8	0.7	WPB 9.6 Tri Rail Lk 400th 6.1 #98 Bountiful 5.6 #92	19.0	1.3 / 34.3
1256 pm	3:14.6 3:15.3	Delray Beach	19	19.3	2.8	Yamato 7.0 Tri Rail	9.5	6.7 / 41.0
115 pm	3:31.8 3:34.6	Dunedin Beach	18	26.4	3.0	4.8 Slow Order	18.6	-3.6 / 37.4
133 pm	3:58.0 4:01.0	Ft. Lauderdale	418	=	25.0		+ 355.6	+ 37.4

Delays:

What constitutes a delay?

A broad definition is any condition which prevents the train from making normal speed between stations or to remain standing at a station in excess of the scheduled dwell time.

A delay begins when the engineer first sets the brake to slow down and continues until normal speed is resumed. This means that deceleration and acceleration are components of the delay -- not just standing time or time lost running at the slower speed. The territory from the beginning to the end of the delay is the Delay Zone.

Station dwell time delays are the amount of time that the train is in the station in excess of its scheduled dwell time. This would include time for second or even third spots. The dwell time would be from the first stop until the last departure, but the delay would be the elapsed time less the allotted dwell time. Although the practice appears to be disappearing, some crews still may report all standing time as a delay. This is not correct, delay is only the amount of time in excess of the scheduled dwell time.

Remember, dwell time for each station is built into the schedule. The actual amount of time the train is at a station should be recorded in the dwell time column of the Summary Sheet (Trip Report) even if it includes some delay.

Killing time is a delay. It comes in two forms. The first is operating slower than the authorized speed in order to kill time before arriving at some point too early. The second is the amount of time standing at a station once the work is completed waiting for the departure time. These must be recorded as delays.

The explanation of station delays should be based upon the function that caused the train to be late -- in other words, the last function or functions performed. If the passengers are loaded on time and there is a 3-minute delay to complete baggage and express work, the delay is baggage and express, not passenger loading. In like manner, if there is a 7-minute delay to water the diner, that is the delay, not mail and baggage.

En route delays are harder to quantify but should include all explanations as to why the train cannot operate at the maximum authorized speed. This would include slow orders, bulletin restrictions, work orders and all similar restrictions. Signals are also a significant cause of delay but are somewhat more complicated to identify.

When an Advance Approach or an Approach Medium signal is encountered, you need to capture the time at a finite point before the engineer sets the brake and the delay continues until a Clear signal is encountered and normal speed is resumed. Signal delays generally fall into two categories. The first is a signal failure where there is a malfunction of the system. This is always a signal delay. The second is where the signals are functioning as intended but are restrictive because there is a train ahead or

an opposing train is clearing. If the cause is known, these delays should be reported as a meet or following a train.

Following are some examples of signal occurrences.

1. Engineer says, "Dispatcher is asleep again," and slows for an Approach signal. He then keys in the dispatcher on the radio but before a conversation takes place, the signal mysteriously clears. This is a delay.
2. You ask the engineer, "Do you normally get a Restricting signal here?" He responds, "No, we normally get a Medium Clear." This is a delay, but the delay is the difference between what the Medium Clear running time would have been and the actual time caused by the Restricting signal. This is not necessarily the track speed.
3. You encounter an Approach Medium signal followed by 3 or 4 Approach signals, a Restricting signal, finally a Clear signal. This is a signal delay, but you do not have to quantify the delay at each signal, only beginning to endpoint for a total signal delay.
4. You receive an Approach Medium signal and you ask the engineer if he normally gets this indication. He responds, "Yes, we go to single track at Ajax." This is not a delay.

5. You receive a similar indication on a two main track rail line and the engineer says, "Yes, we have to crossover to be on the south side for the platform at Elyria." This also is not a delay.

6. A gray area is where two or more main track are in service and the dispatcher periodically crosses you over to go around traffic or to meet opposing traffic. This is a normal operating practice in multiple track territory with reverse signaling. Although it is a good practice to quantify this as a delay, the need to crossover must be considered in schedule construction. When two crossover moves can be attributed to a specific causal factor, such as operating around a freight train or a M of W gang, the justification for reporting it as a delay is much stronger.

What about an engine "not loading properly"?

An engine not loading properly effectively kills a schedule check. First, it is hard to quantify unless you know what the appropriate time should be. Second, if the unit is isolated, it destroys the power-to-weight ratio. A test with two units and 14 cars effectively becomes one unit and 16 cars if a unit is isolated. If this occurs, sit back and relax and watch the dwell times.

In addition to quantifying delays, what else am I looking for?

There are three basic areas you need to observe during the course of the riding program that are by-products or benefits gained by virtue of the fact that you are checking the schedule. The first is the quality of the existing schedule -- does it need to be restrung? Second is the quality of the train dispatching -- how well is it executed? The engineer will often give you valuable tips in this area. Third is the quality of the train handling. It is critical to the integrity of the test. Remember, you are not there to certify or test the engineer, but his handling of the train is critical to the integrity of the test. Operating above the speed limit is rare, below the speed limit is more common. Remember, operating below the speed limit is a delay. When this is observed you have two options -- either start recording the lost time as a delay² which is a continuing and difficult task, or, as an alternative, a firm request should be made to run at the speed limit; a second request is also appropriate if necessary. If this does not result in an improvement, then you categorize the engineer as a Type III engineer and make a note on the riding report accordingly. Engineers are professionals but they also vary somewhat in performance and fall into various general types. The following matrix may appear facetious but it is not. It ties back to the integrity of the schedule check as you will see later.

²Technically, operating above the speed limit is a negative delay and would have to be quantified and factored into the PRT to maintain the integrity of the check.

Engineers Profile:

Profile Handles Train

Engineer Type I Maintains speed limit for miles. Brakes for speed restrictions, kicks off brake at 45, right on 40 mph at beginning of 40 mph restriction, maintains speed through restriction, notches out on throttle as rear car leaves restriction.

Station Stops

Comes in at a good speed; advises spot is second light pole past elevator. Is stopping when conductor says one car; stops on mark.

Engineer Type II Runs within 1 or 2 mph of speed limit, brakes a little early for restrictions, is 1 or 2 mph under restrictions but compensates for same.

Comes into station some-what slower but is well under control when conductor says three cars, stops on spot.

Engineer Type III Runs 3 mph below speed limit, brakes early for restrictions, kicks brake off for 40 mph restriction at 40 and promptly slows to 35 mph but accelerates to 37 mph.

Comes into station slow, not sure where spot is, loses a little time at each station.

Engineer Type IV Runs 3 mph below speed limit unless can get away with 5 under. Brakes early, kicks off brake at 40 for 40 mph restriction, at least 1/10 mile before restriction, promptly slows to 33 mph and jogs through restriction at 33, slow to respond at end of restriction.

Comes into station very slow, about 4 mph; nearly stalls or stalls as conductor calls three cars.

Type I and Type II engineers will probably represent 90% or even 95% of the trips. The quality of these schedule checks will be very good. Type III engineers represent only a small percentage of the trips, but those trips need to be clearly identified as "soft" times so they do not distort the good trips. Some "soft" times include station stops where time can be lost coming into a station slow looking for a spot. On those rare occasions when a Type IV engineer is encountered, throw the riding report away as it has no value and is likely to badly distort the data obtained from the good trips. A conscientious engineer can be a valuable team member. Listen to their advice; they can be a real help.

Calculating the Impact of Delays:

Before we get into the calculation of delays, consider the "3600 Rule." This is an important element in calculating speeds or delays, as follows:

- 3600 divided by Seconds Per Mile equals Miles Per Hour.
- 3600 divided by Miles Per Hour equals Seconds Per Mile.

Example: $\frac{3600}{\text{mph}} = \text{Seconds Per Mile (or)}$ $\frac{3600}{60 \text{ mph}} = 60 \text{ Seconds Per Mile.}$

 $\frac{3600}{\text{spm}} = \text{Miles Per Hour}$ (or) $\frac{3600}{45 \text{ spm}} = 80 \text{ Miles Per Hour}$

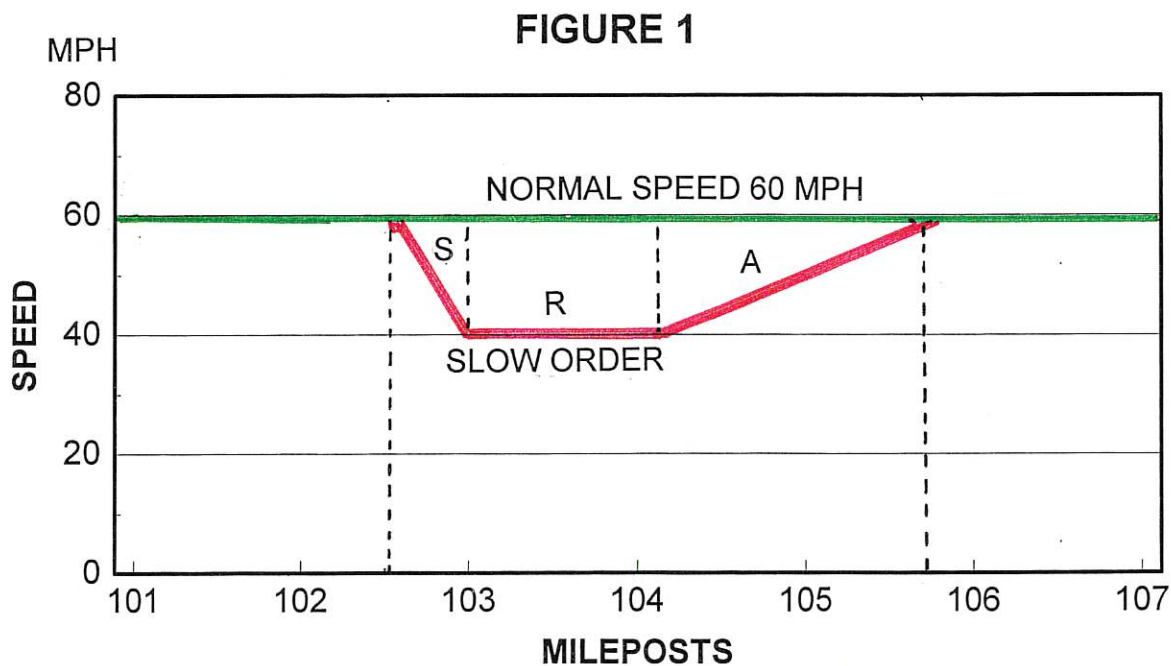
This should be memorized and will become invaluable in calculating delays.

The amount of delay is the difference between theoretical running time, if the train was not delayed, and actual running time.

The delay starts when the engineer first sets the brake to reduce speed and continues until the maximum speed is restored.

In calculating authorized speeds do not overlook the length of the train, generally 0.1 to 0.3 miles, which must be added to each restriction before the train can accelerate. Some road crossing restrictions identified as "head end only" apply only until the crossing is occupied.

Consider the following basic example where a 40 mph slow order exists on trackage that is normally 60 mph: "Do not exceed 40 mph between MP 103 and MP 104."



The delay consists of three components:

1. Deceleration S
2. Restriction R
3. Acceleration A

The total delay (D) is equal to $S + R + A$

In the above Figure, S is the amount of time lost to slow down, R is the time lost due to the restriction and train length, and A is the time lost due to accelerating.

If the train passes MP 102 at 10:40:00, at the maximum speed of 60 mph,
it would pass MP 106 at 10:44:00
Running Time: 4.0 minutes

Actual performance:

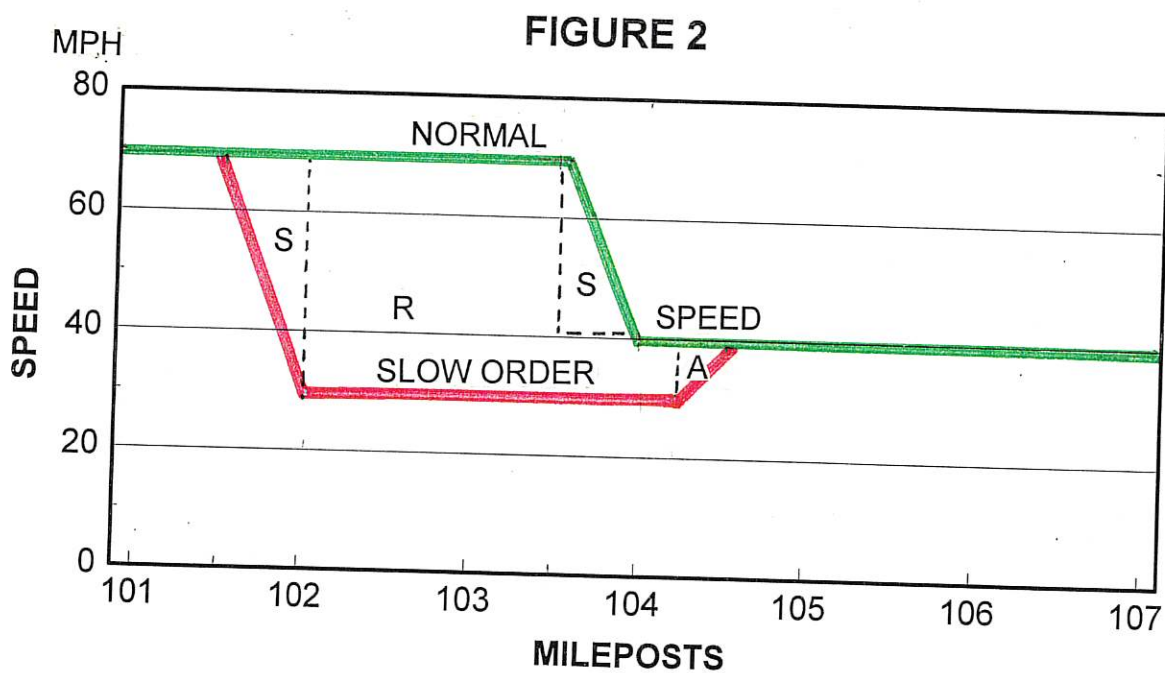
MP 102	at	10:40:00	60 mph
MP 103	at	10:41:44	40 mph
MP 104	at	10:43:14	40 mph
MP 105	at	10:44:33	54 mph
MP 106	at	10:45:35	60 mph

Running Time: 5.6 minutes
Actual Delay: 1.6 minutes

In measuring the delay you do not need the intermediate mile posts, only MP 102 and MP 106. What if you miss MP 106 and catch MP 107? Since the speed limit between MP 106 and MP 107 is 60 mph and the train is running at 60 mph, the amount of delay will not change if it is calculated to MP 107.

It should be noted that a delay cannot be accurately measured from the point where the engineer applies the brake without a finite point where the time can be recorded. The same is true when the maximum speed has been resumed.

In Figure 2 we explore calculations where the maximum authorized speed change within the slow order zone. The restriction is "Do not exceed 30 mph between MP102 and MP104."



In Figure 2 the normal speed changes within the delay zone. The train does not decelerate between MP 103 and MP 104 as it normally would but accelerates after it has left the restriction. This requires separate calculations to determine the delay.

Normal Speed			Slow Order Speed		
MP 101	11:10:00	70 mph	MP 101	11:10:00	70 mph
		Seconds			
MP 101.0-103.5	70 mph	129			
MP 103.5-104.0	70 to 40	33			
MP 104.0-107.0	40 mph	270	MP 107	11:20:33	40 mph
Elapsed Time:		432"	Elapsed Time:		633"
or		7'12"	or		10'33"
The delay is 3'21" or 3.3 minutes.					

Now the question is, how do you calculate the delay?

There are two basic methodologies, remember $D = S + R + A$. Also remember that the amount of delay is the difference between normal speed and actual speed. While the above example is in its simplest form with one normal speed change within the delay zone, it is possible to have five or six normal speed changes and two or three slow order speeds in the same zone which thoroughly complicates the procedure.

In the above example there are two deceleration and one acceleration zones. Excluding these areas, the common area (R) for the restriction is only 1.5 miles in length. This is easy to calculate since it is the differential (or delta) between the two speeds. The difficult calculations are deceleration and acceleration.

The first methodology is using the Acceleration/Deceleration Tables which are included in Appendix I. This is analogous to using the tax tables to determine your income tax. The tables were developed some time ago from actual field observations and show the amount of delay resulting from decelerating and accelerating based upon F-40 locomotives and three different train consists. The tables are a reasonable guide for the new evaluators. Remember, however, the terrain over which the train is being operated may have a material effect upon acceleration characteristics and some impact upon braking distances. The tables are based upon level track and do not compensate for grades.

Over a period of time you may want to develop your own tables based upon different power-to-weight ratios from your own experience, but don't worry about that until you have significant experience.

The second methodology is Speed Averaging. Note the example above in Figure 2 which shows two tables -- normal speed and slow order speed. The normal speed table used speed averaging. Under this methodology deceleration and acceleration calculations are made by averaging the beginning and the final speed and then multiplying the average by the distance in order to determine the time required.

Example: If we assume the deceleration rate is 10 mph per 0.1 mile plus 0.1 mile for actuation, and the speed is to be reduced from 70 mph to 30 mph, it will

require one-half mile. The beginning speed is 70 mph; the final speed is 30 mph; and the average speed is 50 mph or 72 seconds per mile times 0.5 mile or 36 seconds. At 70 mph this same half mile would consume 25.7 or 26 seconds, so the time lost is actually 10 seconds.

Acceleration requires longer distances and therefore more time is lost. If acceleration from 30 mph to 70 mph requires 1.5 miles, the average speed is again 50 mph but the distance is 3 times longer than deceleration. If you again multiply 72 seconds by 1.5 miles, the time to accelerate is 108 seconds. At 70 mph this same 1.5 miles would consume 77 seconds so the time lost is 31 seconds.

The above examples total 41 seconds lost; however, if you did the same calculation using the 2 + 9 speed table, the result would be 43 seconds lost. The table for a three-car train shows a loss of 27 seconds.

When you have to make comparative calculations, make a table such as the one shown, following Figure 3 below. Remember, deceleration must be completed before the restriction is entered, and the length of the train must be factored into the end of the restriction before acceleration can begin.

Let us look at a more detailed calculation where the normal speed changes within a speed restriction. This is not a more complicated process, it is just a longer process because of the speed changes. The methodology is the same.



Important Facts:

<u>Time Table Speeds</u>	<u>Restriction</u>	<u>Actual Time</u>
MP 100.0-102.1 70	Do not exceed 30 MPH between MP 102 and MP 106	MP 101 10:01:30
MP 102.1-103.2 50		MP 108 10:12:59
MP 103.2-104.5 40		
MP 104.5-108.0 75		
		Equals 11 mins. 29 secs. or 689 seconds

The length of the train is 0.2 miles.

- Q. How much time is lost due to the slow order?
- A. It is the difference between what the normal running time would have been and what was the actual amount of time consumed.
- Q. How do I calculate the delay?

- A. You must calculate the amount of time that would have been consumed at normal speeds, as if the slow order did not exist. This is accomplished by establishing what the normal speeds would have been, including deceleration and acceleration. Note the following table. This is the kind of table you should make in your notes to calculate normal running times. It is the red line on Figure III.

<u>Mile Posts</u>	<u>Segment Speed</u>	<u>Average* Speed</u>	<u>Seconds* per Mile</u>	<u>Distance* (Miles)</u>	<u>Time (Seconds)</u>
101.0-101.8	70	70	51.4	0.8	41
101.8-102.1	70-50	60	60	0.3	18
102.1-103.0	50	50	72	0.9	65
103.0-103.2	50-40	45	80	0.2	16
103.2-104.7	40	40	90	1.5	135
104.7-106.2	40-75	57½	62.6	1.5	94
106.2-108.0	75	75	48	1.8	<u>86</u>
					455 Seconds

* These columns may be deleted after the schedule evaluator gains experience.

- Q. Now that the calculation has been completed, how do you determine the amount of delay.

- A. The actual amount of time consumed was 689 seconds
 The above calculation determined normal time 455 seconds
 The delay was 234 seconds
 This equates to 3.9 minutes delay

How accurate are these methodologies? Over years these methodologies have been compared, including Train Performance Calculator (TPC) computer runs. Comparisons have shown a variance in 100 miles of less than 30 seconds; or a field calculation and a TPC run comparison to the second over a 40-mile segment. If the calculations are carefully done, the results are unbelievably close.

Conclusion:

The calculation of delays and breaking a schedule into its basic components is not an exact science; however, it can be done with great accuracy. Armed with the knowledge contained in this paper, you should be able to properly evaluate a schedule. However, one critical element is experience. As you gain experience you should improve your proficiency and the task becomes easier. For those persons who are new riders, it is important to make a training ride with an experienced rider as soon as possible to put into practice what you have learned in the classroom. This should be followed with a second trip on your own. If the end results of the early rides are not good, throw them in the wastebasket just as you would for a trip with a Type IV engineer, so they do not distort the findings of other trips when it comes to schedule stringing. Finally, always remember that safety is of first importance, not only your personal safety but also the safety of other employees and the passengers. The operation of the train must be in conformity with the rules in order to maintain a safe operation. In closing, we would offer this advice: "Have a safe trip."

APPENDIX I
DECELERATION AND ACCELERATION
DELAY TABLES

Note: Distance (miles) shown in the following tables is distance required to accelerate, not to decelerate.

TABLES SHOWING TIME LOST IN
ACCELERATION & DECELERATION
& DISTANCE TRAVELLED IN ACCELERATION

ACCELERATION & DECELERATION DELAYS
ONE F-40 LOCOMOTIVE & THREE CARS

Speed Increase		Distance (Miles)	Time (Sec.):		Speed Increase		Distance (Miles)	Time (Sec.):		Speed Increase		Distance (Miles)	Time (Sec.):	
			Accel.	Decel.				Accel.	Decel.				Accel.	Decel.
0-20 =	25 =	.075	6	3	30-35 =	40 =	.1	1	0.5	50-55 =	60 =	.2	1	0.5
	30 =	.15	10	5		45 =	.2	2	1		65 =	.4	2	1
	35 =	.23	13	7		50 =	.3	3	2		70 =	.7	3	2
	40 =	.3	16	8		55 =	.5	5	3		75 =	1.0	6	3
	45 =	.4	18	9		60 =	.7	8	4		80 =	1.4	9	5
	50 =	.5	20	10		65 =	.9	11	6			1.8	12	6
	55 =	.7	25	12		70 =	1.2	14	7					
	60 =	.9	29	14		75 =	1.5	18	9					
	65 =	1.1	33	16		80 =	1.9	22	11					
	70 =	1.4	38	19			2.3	26	13					
10-20 =	25 =	1.7	43	21	35-40 =	45 =	.1	1	0.5	55-60 =	65 =	.2	1	0.5
	30 =	2.1	49	24		50 =	.2	2	1		70 =	.5	2	1
	35 =	2.5	55	27		55 =	.4	3	1.5		75 =	.8	3	2
	40 =					60 =	.6	5	3		80 =	1.2	6	3
	45 =					65 =	.8	8	4			1.6	8	4
	50 =	0.5	2	1		70 =	1.1	11	6					
	55 =	.1	4	1		75 =	1.4	14	7					
	60 =	.18	6	3		80 =	1.8	18	9					
	65 =	.25	8	4			2.2	21	11					
	70 =	.35	10	5										
20-25 =	30 =	.50	14	7	40-45 =	50 =	.1	1	0.5	60-65 =	70 =	.3	1	0.5
	35 =	.65	17	8		55 =	.3	2	1		75 =	.6	2	1
	40 =	.85	21	11		60 =	.5	3	2		80 =	1.0	4	2
	45 =	1.05	24	12		65 =	.7	5	3			1.4	6	3
	50 =	1.35	29	15		70 =	1.0	8	4					
	55 =	1.65	34	17		75 =	1.3	12	6					
	60 =	2.15	41	22		80 =	1.7	15	8					
	65 =	2.45	45	23			2.1	18	9					
	70 =													
	75 =													
30-35 =	40 =				45-50 =	55 =	.2	1	0.5	65-70 =	75 =	.3	1	0.5
	45 =					60 =	.4	2	1		80 =	.7	2	1
	50 =					65 =	.6	3	2			1.1	6	3
	55 =					70 =	.9	5	3					
	60 =					75 =	1.2	8	4					
	65 =					80 =	1.6	12	6					
	70 =						2.0	15	8					
	75 =													
	80 =													

ACCELERATION & DECELERATION DELAYS
ONE F-40 LOCOMOTIVE & EIGHT PASSENGER CARS (AMFLEET)

<u>Speed</u>	<u>Seconds for: Accel. Decel.</u>	<u>Speed</u>	<u>Seconds for: Accel. Decel.</u>	<u>Speed</u>	<u>Seconds for: Accel. Decel.</u>
0-10 =	6	20-25 =	2	35-40 =	2
15 =	9	30 =	4	45 =	4
20 =	12	35 =	7	50 =	7
25 =	18	40 =	9	55 =	11
30 =	24	45 =	13	60 =	16
35 =	27	50 =	19		
40 =	32	55 =	25	40-45 =	1
45 =	37	60 =	33	50 =	4
50 =	43			55 =	8
55 =	52			60 =	12
60 =	62				
		25-30 =	2		
10-15 =	3	35 =	3		
20 =	5	40 =	5	45-50 =	1
25 =	9	45 =	9	55 =	4
30 =	13	50 =	13	60 =	7
35 =	17	55 =	20		
40 =	20	60 =	27	50-55 =	1
45 =	25			60 =	3
50 =	31	30-35 =	2		
55 =	40	40 =	5		
60 =	48	45 =	9		
		50 =	13		
15-20 =	2	55 =	16		
25 =	5	60 =	23		
30 =	8				
35 =	11				
40 =	15				
45 =	19				
50 =	25				
55 =	33				
60 =	41				

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CONTINUED ON NEXT PAGE ↗

ACCELERATION & DECELERATION DELAYS
TWO F-40's & NINE SUPERLINER CARS
(Page 2 of 2)

<u>Speed</u>	<u>Distance</u> <u>(Miles)</u>		<u>Time (Sec.):</u> <u>Accel. Decel.</u>	
20-65 =	1.9		32"	16"
70 =	2.4		39"	19"
75 =	3.0		46"	23"
80 =	3.7		55"	27"
85 =	4.5		65"	32"
90 =	5.4		74"	37"

<u>Speed</u>	<u>Distance</u> <u>(Miles)</u>		<u>Time (Sec.):</u> <u>Accel. Decel.</u>	
40-45 =	.3		1"	0.5"
50 =	.5		3"	1"
55 =	.8		6"	3"
60 =	1.2		9"	4"
65 =	1.6		13"	6"
70 =	2.1		18"	9"
75 =	2.7		23"	11"
80 =	3.4		30"	15"
85 =	4.2		35"	17"
90 =	5.1		46"	23"

<u>Speed</u>	<u>Distance</u> <u>(Miles)</u>		<u>Time (Sec.):</u> <u>Accel. Decel.</u>	
70-75 =	.6		1"	0.5"
80 =	1.3		2"	1"
85 =	2.1		5"	2"
90 =	3.0		9"	4"
75-80 =	.7		1"	0.5"
85 =	1.5		2"	1"
90 =	2.4		6"	3"